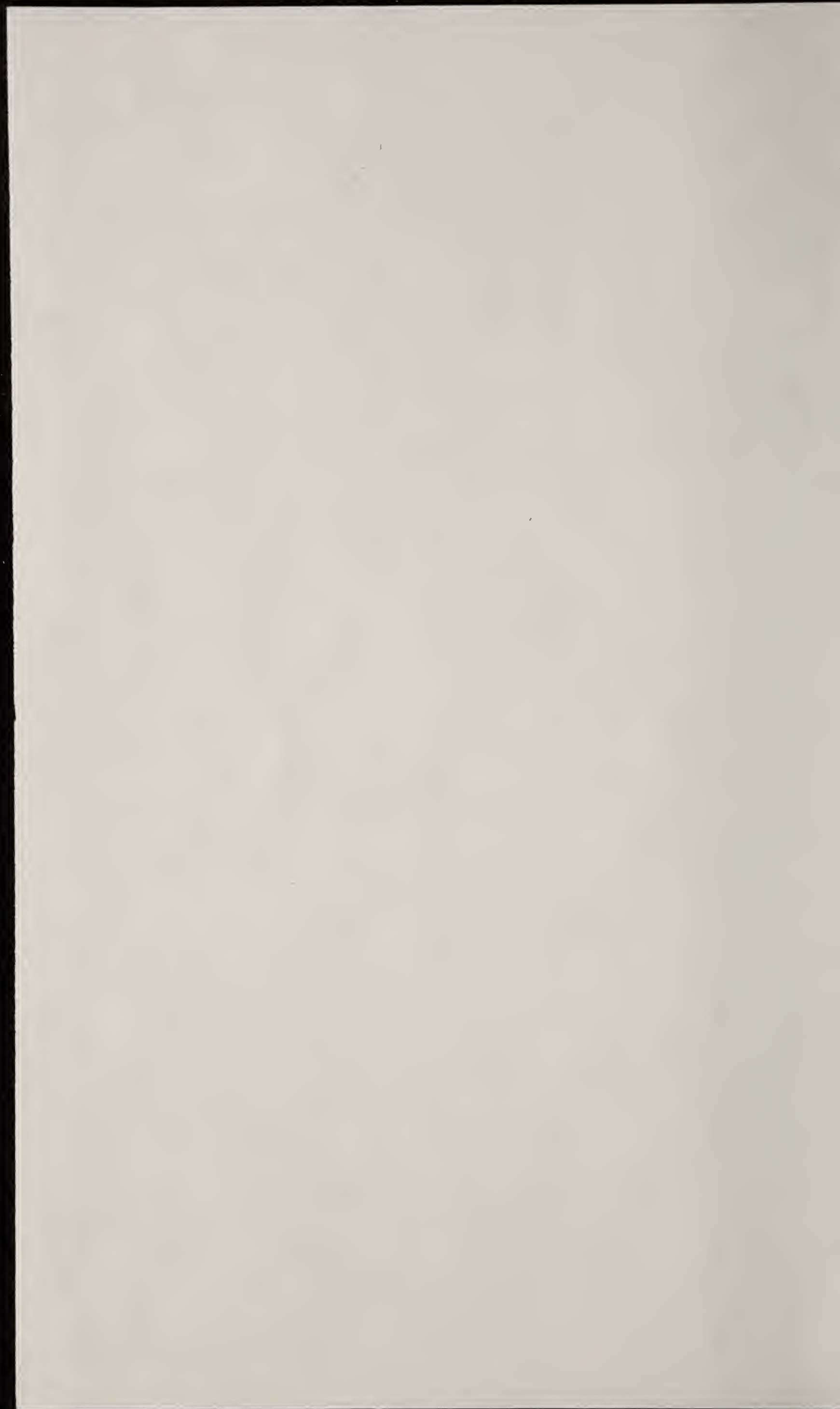
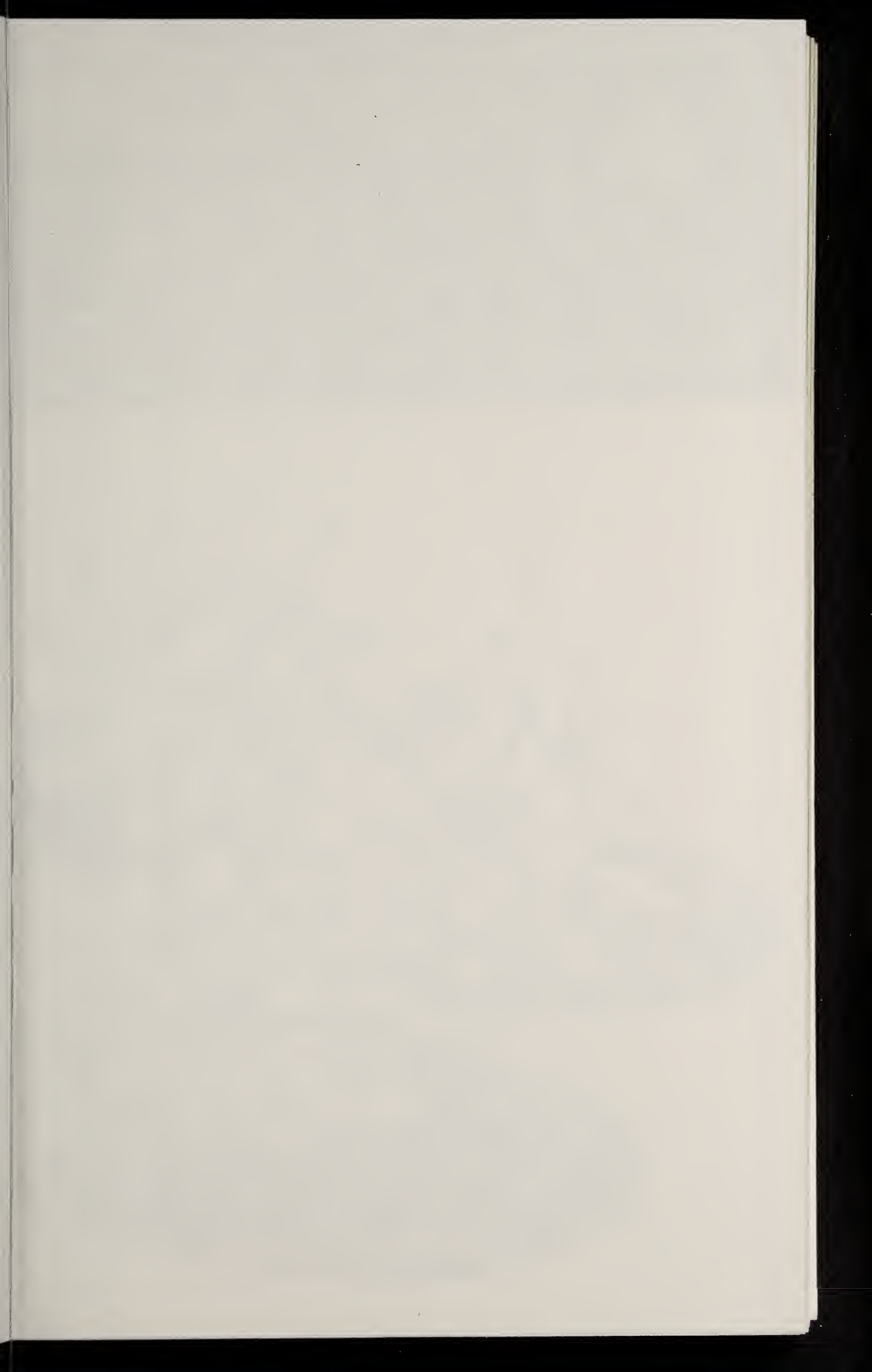


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The Green Thumb



Spring 1985

Volume Forty-two
Number One



The Cover

Water Lilies

Frances Frakes Hansen

The Green Thumb

Spring 1985

Volume Forty-two, Number One

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Velma A. Richards
Editor

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Denver Botanic Gardens, Inc., maintains a collection of living plants, both native and exotic, for the purpose of acquiring, advancing and spreading botanical and horticultural knowledge.

This is a non-profit organization supported by municipal and private funds.

Victoria: Grandest Water Lily of All

by Joseph V. Tomocik

The Denver Botanic Gardens' water garden display of 1984 will be remembered both for its magnificence and the excitement it generated. Half-barrel displays, floating plants, tropical and hardy wetland species and hundreds of water lilies presented a memorable scene of floral beauty. Highlighting the display was the victoria water lily successfully cultivated for the first time at Denver Botanic Gardens.

It is not unusual that the victoria should attract such attention. Since its discovery in 1801 by European botanist Thaddaeus Haenke in Bolivia, many legends have arisen around this most remarkable plant. Stories are told of early botanists falling to their knees in disbelief when encountering this vegetable wonder capable of producing flowers 18 inches across and leaves with upturned edges over 7 feet in diameter.

The genus *Victoria* was established by John Lindley, 19th century English botanist, after he received plant specimens from the Berbice River in British Guiana. The plant was named *Victoria regia* Lindl. in honor of the reigning British queen. In accordance with the international rules of botanical nomenclature it is now recognized as *V. amazonica* Sowerby since *amazonica* was



Victoria 'Longwood Hybrid' flower,
1st day—7 am—9-17-84

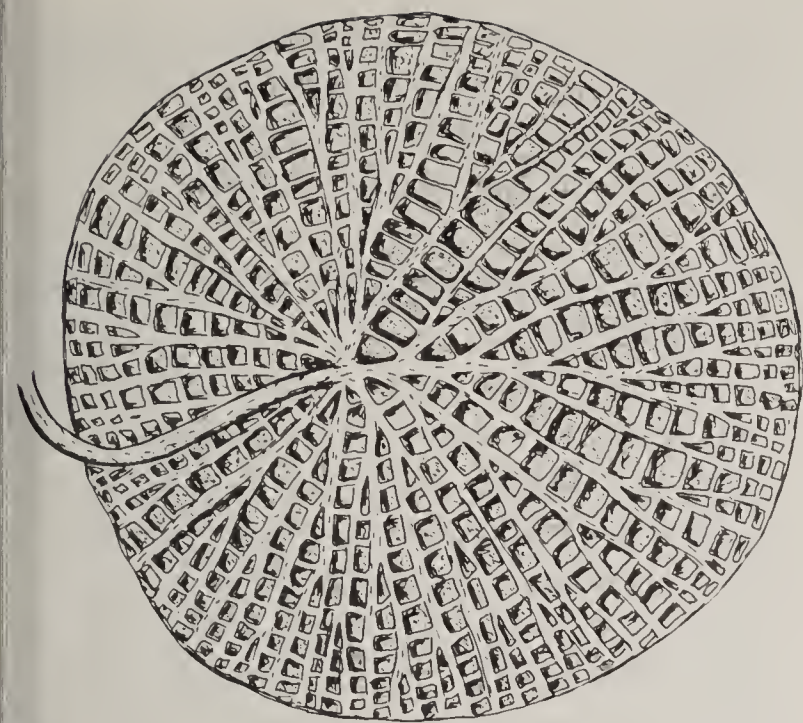
the first specific plant epithet to be applied to the plant in 1832.

The victoria water lily was first cultivated in England in 1849 by Joseph Paxton, eminent gardener of the Duke of Devonshire on the Chatsworth estate. It was successfully grown in Philadelphia in 1851 and in St. Louis at Missouri Botanical Garden in 1894. Upon its first flowering in St. Louis, a special evening reception was held for prominent townspeople. Attendance there the following year increased by one-third because of the excitement generated by this spectacular plant.

Victoria amazonica

The flowers of *V. amazonica*, the largest of all water lilies, are nocturnal, opening on two successive nights. They emit a strong fruity scent reminiscent of ripe pineapple perceptible for 30 feet or more. Oblong petals, pure white the first night, become tinged with pink or red the

Joseph V. Tomocik, has been on the professional gardening staff at Denver Botanic Gardens for five years. His responsibilities include the water gardens display. He also teaches classes on water gardening.



Underside of Victoria leaf

second. The flowers, which close during the day, are protogynous, carpels maturing the first night and anthers the second. Seeds are abundant; a single plant in St. Louis produced two quarts of seed. In South America a farina made from the nutritious, palatable seeds is considered a luxury. Rodents are also fond of the seeds.

Even More Amazing — Victoria Leaves
The common name, giant water-platter,

sometimes given to water lilies of the genus *Victoria*, is derived from the enormous floating leaves. Reactions of disbelief among Denver Botanic Garden visitors attest to the uniqueness of the victoria foliage. The turned up edges of the leaves on mature specimens can measure 8 inches in height. One plant grown in Washington, D.C., had leaves measuring more than 7 feet across. Rate of growth is equally startling. A leaf on the *Victoria* 'Longwood Hybrid' grown at DBG in 1984 gained 8 inches in diameter in a single day.

No less incredible is the unique



Victoria cruziana in Denver Botanic Gardens water garden

structure of the enormous leaves with sharp spines on the bottom. A glance at the undersides of the leaves reveals an intricate pattern of ribs and veins creating a strength in the larger leaves capable of supporting 300 pounds.

Although postcards often picture young girls standing on mature victoria leaves, the weight-bearing capacity of a leaf thus far at the Gardens has been tested only by the mallard ducks that reside here each summer and used the leaves as resting pads in 1984.

So impressed with the structure of the victoria leaf was Joseph Paxton, who first cultivated the plant in 1849, that he constructed a greenhouse for its display at Chatsworth using the engineering principles of its natural design. Paxton's Lily House was the forerunner of similarly designed structures such as the Crystal Palace at the Great Exhibition in London in 1851, and, more recently, the Ridgeway Center at Missouri Botanical Garden in 1982.

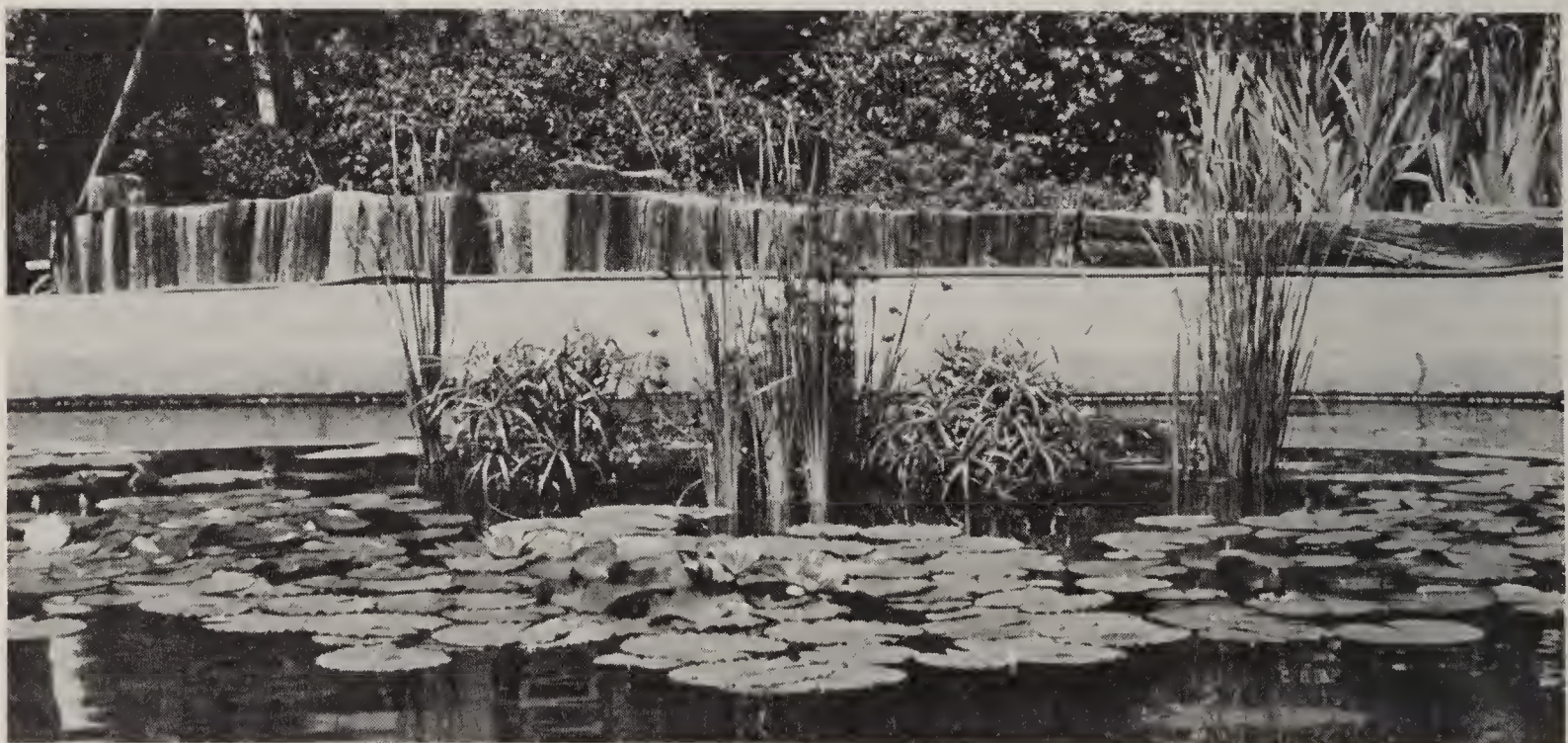
Victoria cruziana

A second species, *V. cruziana* Orb., is native in the somewhat cooler waters of Paraguay, Bolivia and Argentina. Leaves are smaller and the undersides are a violet-blue color as compared with the purplish-red of *V. amazonica*. Hardiness is another important difference. Without artificial heat, *V.*

amazonica cannot be grown in Denver as it requires a water temperature of 85°F. *V. cruziana* can be grown here as can a hybrid of the two species plants.

***Victoria* 'Longwood Hybrid' (*V. cruziana* × *V. amazonica*)**

The 'Longwood Hybrid' victoria resulted from a cooperative effort of Missouri Botanical Garden in St. Louis and Longwood Gardens in Kennett Square, Pennsylvania. Patrick A. Nutt, horticulturist at Longwood, made the pollination with *V. cruziana* the pistillate and *V. amazonica* the staminate parent. The resulting hybrid was first raised at Longwood Gardens in 1961. Predicting the characteristics of a new hybrid is not always possible. Often the unexpected occurs. Such is the case with the new hybrid victoria. The rims of 'Longwood Hybrid' are not as late in developing as in *V. amazonica*, nor as early as in *V. cruziana*. Leaves are intermediate in size. The strong coppery-red color of the exposed outer side of the rim is brighter on the hybrid than in either parent. A feature which makes 'Longwood Hybrid' especially suited to Denver Botanic Gardens' pool is the needle-like spines which extend from the base of the sepals to their tips. These spines thwart the curious and hungry mallards, which at times destroy other tropical water lily flowers.



Victoria Cultivation

Both *V. cruziana* and 'Longwood Hybrid' can be successfully grown in outdoor pools in Denver without artificial heat. Plants may be started from seeds in greenhouses or young plants can be ordered from a number of mail-order outlets.

An area 20 feet across is needed to develop a mature plant in a container 3 feet x 3 feet x 1½ feet deep. Plants raised in shallower containers will not develop to full size but, also, will not require as large a display area. In the Denver area victorias should be planted somewhat shallow—about a foot below the water level—to take advantage of the higher temperatures near the surface. Minimum water temperatures needed for *V. cruziana* and 'Longwood Hybrid' are 70°-75° F.

Victorias are considered to be heavy feeders with one grower recommending fertilizing every 10 days with tablet-form fertilizers. A granular slow-release fertilizer is used for all water lilies grown in Denver Botanic Gardens pool. One application applied at planting time often lasts an entire season.

Notes on 'Longwood Hybrid' grown at Denver Botanic Gardens, 1984

Plant: Victoria 'Longwood Hybrid'

Date planted: June 28, 1984; planted 10 inches below water surface; water temperature 74° F.

Container size: 29 inches x 29 inches x 18 inches deep.

Soil mix: 3 parts top soil, 1 part rotted sod.

Fertilization: 24 oz. slow release (14-14-14) fertilizer and two 21-gram tablets added at planting time. Three additional fertilizations (3 tablets each time) during the summer.

Number of floating leaves produced: 21

Diameter of largest leaf: 48½ inches

Date of first bloom: September 7, 1984

Flower description: First day —

Creamy-white with strong disagreeable odor detectable at 20 ft.

Second day — Red-pink with fruity fragrance. Flower floats on water surface; 10 inch diameter.

Number of blooms to open: 3.

Last bloom: September 22, 1984.

Water Gardens Display, 1985

A dramatic increase in tropical water lily varieties will highlight the 1985 display. Numerous wetland plants will again be shown and will include such tropical species as red-stemmed canna (*Thalia geniculata* L.), green taro (*Colocasia esculenta* (L.) Schott) and umbrella palm (*Cyperus alternifolius* L.). Water irises planted in 1984 should bloom for the first time. Additional native plants will be grown and evaluated. Half-barrel displays will again include floating plants such as water hyacinth (*Eichhornia crassipes* Solms.), water lettuce (*Pistia stratiotes* L.) and one of the smallest flowering plants in the world, *Wolffia columbiana* Karst. Also to be displayed again in half-barrels are two water lilies that performed so well in 1984: *Nymphaea* 'Dauben' and *Nymphaea* 'Pink Laydecker'.

Mid-summer visitors to the Gardens pool will be treated to a spectacular scene—hundreds of blooming water lilies and other wetland plants including the grandest of all, the victoria water lilies.



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Rediscovering Roses for Colorado Landscapes

by Joann Narverud

A look around the Denver Metro area reveals that the large roses botanically classified as "shrubs" and the rambling roses botanists have labeled "scramblers" have been highly regarded as landscape plants since our early pioneers planted their first gardens. The rediscovery of these two types of roses offer gardeners an extensive range of landscaping options.

Since the completion of the Bonfils-Stanton Rose Garden at Denver Botanic Gardens in 1981, the collection has been expanded to include representatives of as many classes of roses, both old and new, as possible. Among these are many exciting plants suitable for a variety of landscaping needs. Some of the most beautiful and useful roses are to be found in the following three classifications:

Old Garden Roses:

By definition, roses in this group are members of rose classifications that were in existence prior to 1867. The gallicas, albas, and species roses are examples.

Shrub Roses:

This class is not easily defined as it has become a 'catch-all' for roses that don't quite fit into any other classification.

Joann Narverud, a professional gardener at Denver Botanic Gardens, has been responsible for the Bonfils-Stanton Rose Garden at Denver Botanic Gardens since it was established in 1981. She is also responsible for the care of the AARS rose test gardens and the ARS miniature rose test gardens.

Generally, shrub roses are large, hardy shrubs that were introduced after 1867 and do not belong in the 'Old Garden Rose' classifications.

Ramblers:

These roses are wild species and their closely related hybrids, whose growth habits tend toward long trailing canes, one profuse annual flowering, and glossy, disease-resistant foliage.

There is a rose for almost every situation, whether it be spectacular accent plantings, informal hedges, or ground covers.

Accent Plantings

Among traditional landscaping plant materials, there are few that make as bold a statement as the following roses.

***Rosa* cv. Fruhlingsgold**

Classified as a hybrid *R. spinosissima* L., this rose attains a height and breadth of 6 feet within three years. In early May, the plant is literally covered with nasturtium-red buds unfolding into large, fragrant, single cup-shaped flowers of an unusual light golden yellow. Although 'Fruhlingsgold' blooms only once each year, its softly wrinkled, light green foliage and big orange-red hips carry it through the season beautifully.

***Rosa hugonis* Hemsl.**

An extremely valuable rose for landscaping, it is fast growing, thrives in alkaline soils, and requires less water

than most shrubs of equal size. One of the first roses to bloom each spring, its 6-foot tall, slightly drooping canes are clothed from top to bottom with sweet smelling, bright yellow double flowers. The unique foliage of leaves with five to eleven leaflets gives the plant a lacy appearance.

***Rosa rugosa* Thunb. var. *rubra* hort.**

Brilliant, magenta hibiscus-like blossoms appear in early June on 5-foot tall plants, and continue throughout the summer and early autumn months. Beginning in mid-July, large orange hips are produced along with the flowers for the duration of the growing season. All rugosas have large, leathery, dark green foliage.

***Rosa rubrifolia* Vill.**

Commonly known as the red-leaf rose, this plant really shines during the late autumn and winter. Small rose-pink flowers in mid-June are followed by half-inch, bright orange-red fruits which are held until spring. Performing equally well in sun or shade, this rose has reddish foliage in full sun and takes on a blue-gray cast in shade. Mature specimens reach a height of 6 feet and are of graceful habit. This species suckers a bit but is easily controlled.

Informal Hedges

Many roses are suitable for borders and informal hedges. The effects that can be created are as variable as the heights, forms, and colors of the varieties available.

***Rosa acicularis* Lindl.**

A personal favorite, *R. acicularis* attains a height of approximately 3 feet and has a beautifully rounded form. In early May, the plant is covered with hundreds of deep-pink single flowers followed by short lived, pear-shaped hips. It is an attractive alternative for the smaller forms of spirea and similar shrubs in Colorado landscapes.

***Rosa spinosissima* L.**

The Scotch rose is a pretty, ferny-leaved plant that tends to wander a bit, thus it is



Hips of *Rosa rubrifolia*

useful as a very tight hedge. Its suckering growth habit is not vigorous enough to become a serious problem and any unwanted suckers are easily removed. *R. spinosissima* blooms at the same time as *R. acicularis*, its graceful arching canes decked out in hundreds of thick petaled, creamy-white flowers with golden centers. Its fruity fragrance is exquisite. In autumn, maroon-black, shining hips cover the plant and hold well into November.



Rosa rugosa rubra

***Rosa* cv. Alain Blanchard**

Introduced in 1839 and possibly of *R. centifolia* L. x *R. gallica* L. parentage, this rose attained its maximum height of 4 feet in three seasons. In mid-June it is blanketed with 3-inch, semi-double, crimson-violet flowers with maroon spotting and large golden centers. Try this worthy rose against a house of blond colored brick or along a cedar fence to bring out its spectacular coloring.

***Rosa* cv. Empress Josephine**

This is one of the most well known roses of the gallica group and one of few old garden varieties that is practically thornless. Its leaves, grayish with noticeable corrugation at the veins, give the 4-foot tall plants a soft mounded appearance. Once seen, the flowers make 'Empress Josephine' one of the most memorable of all roses; they are a rich medium rose color flushed with lilac and purple and veined with a deeper tone. This papery-textured rose would be a beautiful addition to any garden. It has been in botanical literature as early as the year 1583; one look will tell you why!

Ground Covers

Roses should also be prominent in landscaping as ground covering. With the exception of two Japanese species and a *R. kordesii* Wulff. hybrid, the roses

recommended for this situation belong to the class of roses known as Ramblers. There are many varieties of rambling roses available for use as ground covers and three that are especially nice are *Rosa* cv. Alberic Barbier, *Rosa* cv. Dortmund, and *Rosa* x *paulii*.

***Rosa* cv. Alberic Barbier**

A hybrid of *Rosa wichuraiana* Crép. x *Rosa* cv. Shirley Hibberd (tea rose) parentage, this plant creeps more than it rambles. Its long, very prostrate canes are clothed in glossy dark green, almost evergreen foliage. Creamy yellow flowers appear in early June and, because they are small and very double, give the garden a delicate appearance. When planted 3-4 feet apart, 'Alberic Barbier' will become a dense mat approximately 8 inches tall within two growing seasons, a wonderful plant for bank or ground cover.

***Rosa* cv. Dortmund**

Throughout the season this beautiful 24-inch tall ground cover, a *R. kordesii* hybrid, is covered with clusters of large, single red blossoms with prominent white "eyes." Extremely vigorous, its ruffled dark green glossy foliage is truly spectacular. When planted 6 feet apart, 'Dortmund' will densely cover an area in two growing seasons.

***Rosa* x *paulii* Rehd.**

A *R. arvensis* Huds. x *R. rugosa* Thunb. hybrid, *Rosa* x *paulii* inherited its growth habit and flower form from the first parent and its gorgeous foliage from the second. The canes on this 12-inch tall creeper grow to 10 feet in only one season, assuring dense coverage with very few plants. Its 3-inch, five-petaled, brilliant white flowers appear in early June and have the fragrance of cloves.

Also excellent subjects for ground covers are two miniature Japanese species roses grown at Denver Botanic Gardens for the past three years. As it has recently been brought to our attention that they are incorrectly named, reference to them is by number, *Rosa* species #1 and *Rosa* species #2.





***Rosa* species #1**

Never exceeding 18 inches in height, this little gem blooms only once each year and even in full bloom the small, single, white flowers are not easy to see against the variegated light green and white foliage. The true value of this plant is in its spreading, yet compact growth habit and beautiful leaves. When planted 2 feet apart, *Rosa* species #1 will completely cover an area within two years, and unlike many miniature roses, seems to be unattractive to all common rose pests.

***Rosa* species #2**

Groundcovers less than 4 inches high and as attractive as this one are rare. The delicate foliage of this rose is soft, dark olive green with tiny leaves and its 2- to 3-foot canes are densely covered with prominent hooked thorns. Given adequate water in partial shade or full

sun, and spaced 18 inches apart, *Rosa* species #2 will form a dense, prickly mat in just two growing seasons.

Be sure to mark your calendars for May and June and visit the Bonfils-Stanton Rose Garden at Denver Botanic Gardens. Come rediscover many beautiful roses that have delighted plant lovers for more than four centuries. Rediscover roses not only for their lovely flowers, but also for their delightful fragrances and colorful fruits which offer a healthful bonus of vitamin C when eaten fresh or brewed in tea. ♀

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Rosa X Paulii

Annuals: Ad-lib

The tips given here are from conversations with Richard Martinelli and William O'Hayre, DBG staff members who are in charge of major areas of the outdoor gardens including plantings of annuals.

Soil Preparation

It is best to rough spade in the fall, although many people will wait until spring when the gardening bug hits. Add some humus—manure, compost or peat moss—to the flower beds. If this is done in the fall, the humus has time to break down in the soil and can be re-spaded or rototilled in the spring before planting. Perhaps our method at the Gardens might be helpful. We always give the beds a crown—that is, the center of the bed is several inches higher than the edge where the bed meets a walkway or grass, and the edge is a few inches lower. The surface of the soil should be raked smooth to preserve this crown. When rough spading throw soil from the edges toward the center of the bed to avoid overspill onto walks or turf.

To give the bed a boost add a high nitrogen fertilizer at planting time. Although this idea is controversial it can offer quick cover and will lessen weed problems. If the plants need a little help after they are established use a fertilizer designed to increase blooming. Little or no fertilizer is needed after mid-summer.

How to Plant Annuals

Each flower will have its own rec-

Richard Martinelli has been on the professional gardening staff at Denver Botanic Gardens since 1972; William O'Hayre, also a professional gardener, has been with the Gardens since 1980. Both were previously employed in other areas of the city by the Denver Parks and Recreation Department.

ommended spacing between plants; check the seed packet or plant label for this information. Petunias, for example, should be about a foot apart. Depending on the desired effect, either stagger the rows or set the plants in a grid pattern. Remember, the recommended spacing for each plant applies in all directions.

A planting plan is essential for color and its effects and for proper grouping of plants according to height and spread at maturity. The appearance of newly purchased plants is no indication of their growth habits.

In setting out the plants place them deep enough to allow for settling of the newly worked bed. If the plants are set level with the surface, within a few weeks the root ball will be left high and dry. By pressing the root ball of an annual into the ground a little bit it will be at the correct level when the surrounding soil has settled. Before putting the root ball into the ground, score it (use your fingers to rough it up) so the plant roots will get a better start at reaching out into the surrounding soil.

Watering

The initial watering is very important. In fact "puddling them in" is descriptive. Water them well and give that water a chance to be absorbed. Then puddle them in again. Check to make sure there has been good absorption of water. Keep the soil moist until the plants are well established.

Another tip related to watering is to



Petunia 'Maxi Plum'



Azalea-flowered snapdragon



Impatiens 'Huckabuc'

cultivate with a hand cultivator first and water the following day. If the surface of the soil looks dry and the plants look as if they may need some water, break the crust to see if there is dampness down about an inch or so. If there is, cultivate the bed so this moisture can reach the plants. Water again when needed. Cultivation not only helps water percolation but also allows air to the roots and discourages weeds. Overwatering can be a problem. Many plants such as petunias and geraniums like it a little on the dry side. Too much water stunts plants, causes yellowing, and brings on disease—the results of oxygen starvation.

As the plants reach their peak their roots have grown much deeper and need less water. After the annuals have filled in well they cover the soil and provide a natural mulch which also conserves water.

Some gardeners use grass clippings for mulch; this is all right if the clippings are spread thin enough that they can dry. A bit of caution—be sure not to use lawn clippings that have been sprayed with herbicides.

Pests and Disease

Aphids, spider mites and leafhoppers are frequent pests and can be controlled with appropriate insecticides such as Malathion, Diazinon or Sevin which are fairly safe for use in home gardens. Although leafhoppers themselves are not especially damaging, they do transmit harmful diseases.

If fungus is apparent, you're usually too late. Plants such as zinnias and cannas, which are susceptible to powdery mildew, can be sprayed in late June or early July with a fungicide such as Benelate. It will also control rust on snapdragons. A fungicide can be used as a preventative as well as a cure.

Some Favorite Annuals **Ornamental Peppers**

Promising among the new annuals are ornamental peppers prized for their varied foliage as well as their different colors and shapes of fruit. Some of them,



Annual gardens at Denver Botanic Gardens

having been dried, were popular items at the Gardens' annual holiday sale.

Basil 'Dark Opal'

The foliage of basil adds contrast to a border and is especially nice for edging a walkway. One important tip—don't let it go to seed. Pinch off any flower stalks just as they are blooming to keep the basil strong. When you trim the top quarter of the plant for shape and bushier growth habit, you will notice that the leaves underneath are more green than dark purple. No need to worry—their dark purple color will return in a week or two.

Snapdragons

Wonderful flowers in many heights and rich colors, snapdragons demand constant care. They should be pinched back to remove seed pods and encourage blooms throughout summer. We have had good results when snapdragons were combined with 'Victoria' salvia in a strikingly beautiful bed. They are both about the same height and would do well in a semi-shaded area.

Coleus

Prized for its colorful foliage, coleus lends a cheery accent to the semi-shaded garden. 'Golden Better' and 'Firefly' are exceptions and will thrive in full sun.

Impatiens

Good for shade to semi-shade, impatiens provides bright flowers on lovely foliage for hard-to-fill situations.

Morning sun is best with shade for mid-day and afternoon. Plants are generally problem-free.

Petunias

Easy to grow, petunias offer an immense variety in color, form and habit. The multifloras provide compact, tight growth even though the flowers are smaller than the grandifloras. All annuals should be deadheaded (spent flowers removed) in July—a cosmetic procedure to keep beds clean and plants blooming well.

Cannas

Although grown from tuberous rhizomes rather than seeds, cannas are popular in the Denver area as annual bedding plants, and were spectacular at the Gardens last year.

They should be taken from storage in early March, cleaned and divided and planted indoors in pots with the "eyes" just visible at the soil's surface. Wait until June before setting them outdoors, preferably in full sun. They are most showy in August and September. To keep them flowering, cut the spent blossoms just above the top leaf on the stem; cutting lower than this removes the next bloom. 'President' and 'Los Angeles' are cultivars that have been popular at the Gardens. After the fall freeze, the stalks may be cut to 6 inches, the tubers dug and stored for the winter in a dry place at about 40° F.



Keep 'em Covered with Salpiglossis

by Bernice E. Petersen

"Keep 'em covered," the edict of the T.V. western, is common gardening practice for the seasoned spring bulb enthusiast. Many fill the void left by early bulbs with candytuft, sweet william, or verbenas, but have you tried salpiglossis, the velvet-tongue flower?

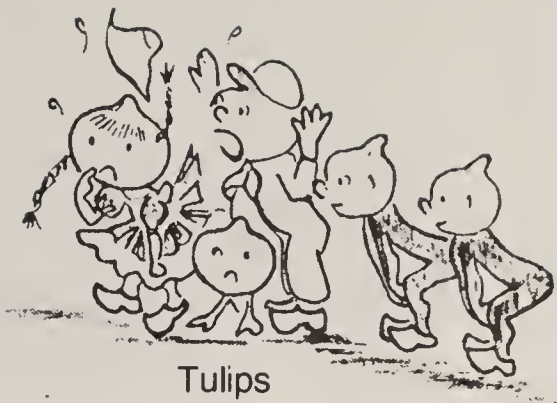
Neither the botanic nor common name adequately depicts the sheer loveliness this annual displays. A member of the nightshade family, the 30-inch plant has the customary sticky foliage of its relatives—petunia, tomato, and tobacco. Its velvety blossoms are funnel-shaped and bloom in a delightful array of colors, all delicately veined with gold; brown, deep blue, red, pink, purple and yellow.

A saleslady introduced "sappyglossis" in our first year of gardening. For us it has been true "idots' delight"; for lo, these many years, we have been rewarded with flowers of unusual beauty. So distinctive was our first effort, a bed about six by 30 feet at roadside near our mailbox, that our suburban postman left a note asking the name of the flowers and adding that they were the only ones on his route.

A wonderful cut flower, the salpiglossis is sold only in mixtures; yet the colors blend as harmoniously as those in rich brocade. Plants may be purchased in flats



Salpiglossis



Tulips

in spring. According to some, seeds are difficult to start. Despite our ignorance, for us the seed has germinated and reseeded readily. In fact, soil has been transferred from one bed to another with no concern for future seedlings, but an excellent unplanned bulb cover resulted. Plants respond to a minimum of water, a prime consideration when covering bulbs.

Why don't you try "keeping 'em covered" with velvet flowers? No sheriff's badge required. *



Salpiglossis

Bernice E. Petersen has shared her extensive gardening experience with readers of the magazine for many years. This article appeared in *The Green Thumb* 17(4):119 (May 1960) under the byline Edna Lucas which she occasionally used.

Spiranthes diluvialis: Clear Creek's New Orchid

by C. J. Sheviak

Orchids generally are thought of as exotic plants of tropical rainforests, and people often are surprised to learn that many species occur in the United States. The suggestion that species unknown to science could still, at this late date, occur in this country evokes disbelief, even among botanists. The recent discovery of one such plant in the Denver area is a remarkable example of the discoveries that continue to be made in this interesting group of plants.

The genus *Spiranthes* is a primarily North American group of small-flowered terrestrial orchids known popularly as ladies' tresses, a name derived from the spiraled arrangement of the flowers and braid-like arrangement of the floral bracts. The genus is notoriously difficult taxonomically due in part to the relatively minor nature of the morphological differences between species and to the loss of many of these features when plants are preserved as pressed herbarium specimens. More fundamentally, complex evolutionary processes in the group make the interpretation of morphological characteristics, the basis for classical plant systematics, unclear. This situation has lent the group its reputation and resulted in the persistence of problems to the present day.

Progress has been made in the last fifteen years or so. Modern methods of systematic investigation, including multivariate statistics and cytology (the study of chromosomes) have been applied to the group and have contributed to recent advances in our understanding. Since 1973, three new species and one variety have been described in North America, and all indications are that this trend will continue.

***Spiranthes cernua* complex studied**

In 1968, I began a study of the *S. cernua* (L.) L. C. Rich. complex, a group of species occupying the eastern two-thirds of the United States and adjacent Canada. This study disclosed the presence of a previously unrecognized species, *S. magnicamporum* Sheviak, a prairie plant which occurs across much of the plains region (Sheviak, 1973). It largely replaces *S. cernua* westward, and much of the material formerly treated as *S. cernua* from this region proved to be referable to *S. magnicamporum*. During the course of this work, I investigated the basis of reports of *S. cernua* from Utah. These were based on a collection made by Marcus Jones at Salt Lake City in 1880. Jones determined his material as *S. romanzoffiana* Cham., a species of transcontinental range widespread in the West. Oakes Ames, in a monograph of the genus in North America (Ames, 1905), cited Jones' collection under this species, but Donovan Correll subsequently reported it as *S. cernua* (Correll, 1950).

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This disparity of treatments by the two authorities on the genus was interesting, especially in light of the new information I was obtaining on *S. cernua* and *S. magnicamporum*. Consequently, in 1976 I examined the specimens and found them to be neither *S. cernua* nor *S. romanzoffiana* but rather morphologically intermediate between *S. romanzoffiana* and *S. magnicamporum*. On the basis of their intermediate morphology, they appeared to be hybrids of these two species, yet *S. magnicamporum* was not known to occur in the intermountain region.

Search for herbarium specimens

A search of several western herbaria consequently was made in an effort to locate specimens of this species or additional intermediate material. No specimens of *S. magnicamporum* were found, but several collections of plants similar to the Jones plants were located. These had been collected at widely scattered sites in the Great Basin. Hence, it appeared that they did not represent merely a local hybrid, and an attempt to assess their morphological distinctness was begun, employing statistical methods and the background knowledge obtained from several years of work in the genus. It immediately was apparent, however, that live material would be invaluable, for cytological study had been the basis for much of the success I had had in the *S. cernua* complex. Due to the distances and expense involved in collecting, however, it did not appear likely that the necessary material could be obtained.

Live plants from Clear Creek studied

In 1980, a population of similar plants was discovered along Clear Creek at Golden by Stanley Smookler and brought to my attention by Drs. Robert Bye and William Weber of the University of Colorado. This discovery raised a great deal of interest locally, and William Jennings, with whom I had corresponded previously, contacted me. As a result of our discussions, he, Lucian Long, and Dr.

William Gambill collected blooming material in 1981 and sent it, under the auspices of Denver Botanic Gardens, for study. These plants allowed me to compare pressed specimens with live plants and to assess morphological features under these different conditions. Most importantly, they provided cytological material, and the data derived from it proved to be the key to an understanding of the plants.

My earlier chromosome work in the *S. cernua* complex had shown the importance of differences in ploidy level to the evolution and species limits in the group. Species exhibited either the basic number of chromosomes for the group (diploids) or twice this number (tetraploids). Differences in chromosome number often isolate plants genetically and mark different species. Hybridization of diploid and tetraploid plants ordinarily produce triploids, plants with an intermediate chromosome number. Such plants are sterile because of the unbalanced assortment of chromosomes. Each chromosome from the tetraploid parent has a duplicate with which it can pair in meiosis, which leads to pollen and ovule formation. The chromosomes from the diploid parent, however, are not duplicated and cannot pair properly. As a result, pollen and normal seeds are not formed.

Chromosome numbers determined

The cytology of the Clear Creek plants was most significant. Plants of *S. magnicamporum* have 30 chromosomes throughout the species' range. In *S. romanzoffiana*, several numbers are known in various portions of the species' range, the most widespread being 44. The Clear Creek plants proved to have 74 chromosomes, twice what one would expect in a hybrid of *S. magnicamporum* with 30 and *S. romanzoffiana* with 44. This number is the key to understanding the origin and status of the Clear Creek plants and those from the Great Basin. As suggested by their morphology, the Clear Creek plants arose through hybridization of *S. magnicamporum* and



Spiranthes diluvialis



S. romanzoffiana. By chance a doubling of chromosomes occurred in one of the hybrid offspring. Each chromosome is consequently represented twice, resulting in fertility and ability to reproduce. The genetics of such plants furthermore dictates that they breed true from seed, unlike normal hybrids. It also suggested that they represent a distinct, previously unrecognized species, because they reproduce in kind and exhibit a unique set of morphological characteristics. Several questions remained, however. Were all plants on Clear Creek the same cytologically? Were the plants from the Great Basin the same as the Clear Creek plants, as had been suggested by morphological study? It was apparent that additional field work would be necessary to properly answer these questions.

Clear Creek orchid named

In 1982 and 1983, Denver Botanic Gardens provided funding for field work throughout much of the West. This enabled me to obtain cytological samples from numerous plants along Clear Creek and at sites in the Great Basin, and to compare further the morphology of plants in different populations. Study of numerous live plants in Utah populations and along Clear Creek confirmed their morphological similarity and helped to develop a concept of their range of variation. Most significantly, I was pleased (and not a little relieved) to find the same chromosome number in Utah and Clear Creek plants. Hence, the morphological distinctions of these plants and their peculiar cytology indicated that they represented a distinct species, and, in 1984 I published the new species *S. diluvialis* Sheviak.

Spiranthes diluvialis appears to have

arisen during a pluvial period in the Pleistocene glacial epoch. The much wetter climate fostered the growth of lush grasslands and the development of extensive lakes throughout the Intermountain Region and Southwest. Evidently *S. magnicamporum* was present in the region (a conclusion supported by its present occurrence in the upper Rio Grande valley) and hybridized with the common *S. romanzoffiana*, giving rise to *S. diluvialis*. The name "*diluvialis*," meaning "of the flood," was chosen to reflect both the plants' streamside habitat and pluvial origin.

More Problems in the enigmatic *Spiranthes*

It is perhaps fitting that the work on *S. diluvialis*, which began in an effort to tie up a "loose end" in another project, has itself brought to light other problems. Several other enigmatic *Spiranthes* are now known to occur in the West. Work now in progress promises to generate still more information on this interesting group of plants. ♀

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FOCUS ON TI, *Cordyline terminalis*, IN THE BOETTCHER MEMORIAL CONSERVATORY

by Peg Hayward

Cordyline is a small genus of evergreen plants, closely related and frequently confused with *Dracaena*, belonging to the agave family, but formerly of the lily family. Both red and green ti are classified as *Cordyline terminalis* (L.) Kunth. The difference in the two is that red ti has kept its ability to produce seeds whereas green ti has not.

C. terminalis, originally native to India, is cultivated extensively in all tropical countries for its highly ornamental foliage. *Cordyline* is from the Greek *kordyle*, a club, in reference to the large, fleshy clublike roots produced by some species. *Terminalis*, meaning at the end, refers to the fact that the flowers are borne at the tips of the leaf crowns.

The ti plant, in no way related to the beverage tea, grows 12 or more feet in height. Single or multiple stems ringed with leaf scars support clusters of tapering, leathery leaves at least 12 inches long and 4 inches wide. Leaves are arranged in close spirals at the top of each branch, giving the crown a palmlike effect. Periodically, panicles of numerous small, fragrant, pink or light violet

flowers emerge, followed by occasional berries which change from yellow to red.

Ti has always played an important role in the life of Hawaiians. It was an emblem of divine power and the Hawaiian priests often wore leaves of ti around their necks. Many natives believed that a hedge of ti planted around the house would ward off evil spirits and would bring good luck.

Ti leaves are strong and do not wilt quickly, so they proved useful to the early Hawaiians for many purposes. They were made into whistles, raincoats and sandals. They were used to thatch houses and served as fodder for horses and cattle. In the days before plastic bags and refrigeration, ti leaves were indispensable for food storage. The thick roots, sometimes weighing over 30 pounds, provided food in times of scarcity. An intoxicating beverage was distilled from a fermented mash made of the baked root.

Ti was abundant both in the wild and in cultivation. If the plant was destroyed by a storm, its large amount of stored underground energy allowed it to survive and sprout forth anew.

Even today ti has many uses. Shredded fresh green ti leaves are fashioned into skirts for hula dancers. Meat or fish wrapped in ti leaves and cooked is standard fare at a luau, and the leaves

Peg Hayward has been active in the conservatory tour guide training program from its beginning, and serves on both the editorial and education committees of the Gardens.



Ti, *Cordyline terminalis*

are also used to cover the table where a feast is served. Ti leaves from florists are popular for flower arrangements. Numerous hybrids of red ti have been developed and are sold as beautiful foliage house plants. They are available in maroon, red-white, yellow-green and other colors as well.



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Integrated Pest Management for Home Landscapes

by John Brett

Integrated Pest Management (IPM) is a concept of pest control that relies on many techniques rather than a single one. A common assumption about IPM is that it is a non-pesticide or "organic" approach. While one of its goals is to decrease pesticide use for both environmental and economic reasons, a primary intent is not necessarily to eliminate pesticides however desirable that might be, but rather to make the use of chemical pesticides more efficient and effective, thereby reducing the quantity used and the number of applications required. Pesticides become one weapon in a large arsenal, not *the* weapon to be used against all foes. There is some indication that more pesticides find their way into the environment through over-use, improper disposal, and carelessness in urban regions than in agricultural areas. This is a significant consideration, given that most of us live in urban settings and, therefore, are potentially exposed to these chemicals. Research is just beginning on pesticide levels in urban areas; thus concrete information is not yet available. By adopting an IPM approach to pest control in your garden you can ultimately improve the health and well-being of your garden and decrease the use of chemical pesticides.

John Brett is continuing to work with the IPM program at Denver Botanic Gardens while attending graduate school at the University of Colorado in Denver.

Several examples of successful use of an IPM approach at Denver Botanic Gardens will illustrate the concept. When DBG began development of the Chatfield Arboretum site several years ago a major problem was the abundance of musk thistle (*Carduus nutans* L.), a biennial weed that spreads rapidly and forms dense thickets wherever the soil has been disturbed. It also occurs as scattered individuals and loose colonies in undisturbed sites. Three strategies for control were used. For large flat areas (abandoned fields) mowing was the most effective method. Just before the plant was ready to flower the field was mowed. Because musk thistle is a biennial growing vegetatively one year and flowering the next, mowing at this stage killed the plant which had used up all its nutrient reserves to produce the flower head and thus was unable to produce secondary growth. Timing was critical to success in this part of the operation. Cutting too early would allow the development of lateral buds, resulting in 6-7 flowers instead of one or two; cutting too late risked having flowers sufficiently developed that they could mature seed even after being cut.

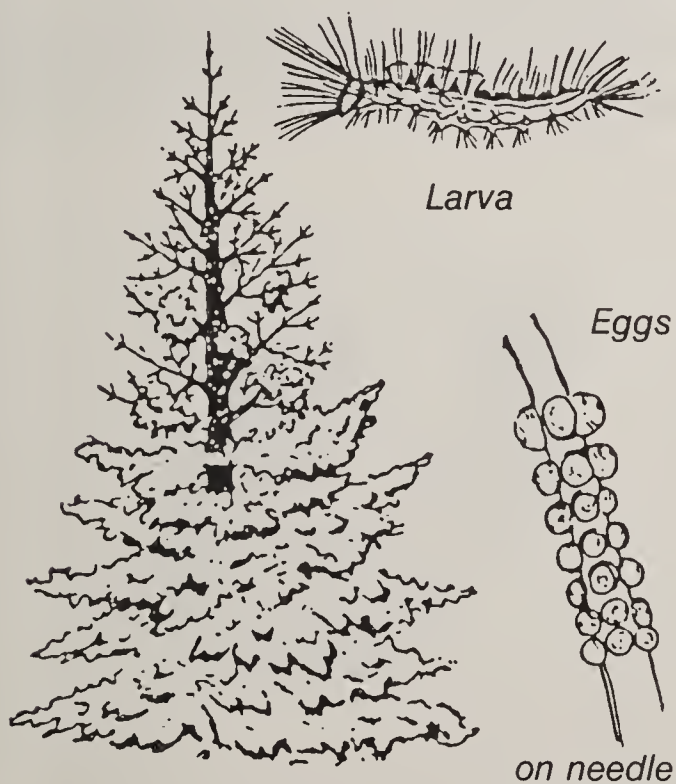
In those areas where cutting was not possible a chemical control was used. This involved selective spraying of individual plants with hand-held equipment.

The third tactic was biological. A musk thistle seed weevil (*Rhinocyllus conicus* Froelich) was introduced. While the

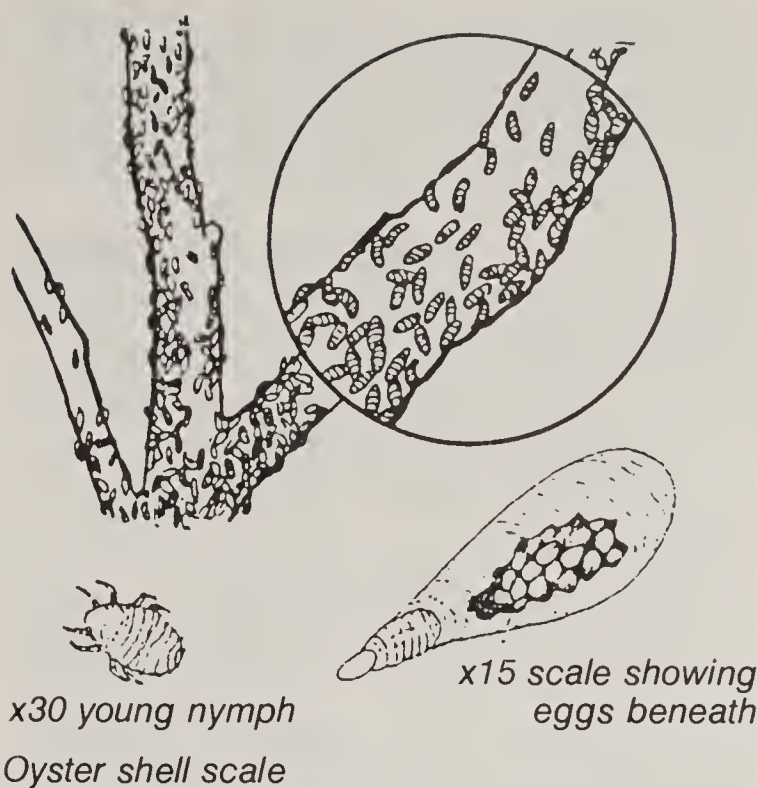
weevil by itself will not eliminate the weed, it will eat a significant number of seeds from the remaining plants, preventing rapid reintroduction when other control measures are slowed.

This three-pronged approach was maintained for several years and has effectively eliminated the musk thistle as a major weed problem at the Arboretum.

Two other examples involve insects as pests instead of heros, both at the York Street site of Denver Botanic Gardens. A major insect pest on two of Colorado's beautiful natives, the blue spruce and the Douglas fir, the Douglas fir tussock moth (*Hemerocampa pseudotsuga* McDunnogh). The larvae of this moth will defoliate blue spruce and Douglas fir starting from the top down, eventually killing the tree if not controlled. The usual control is to spray with the pesticide Sevin or Sevimol (Sevin with molasses) to kill the emerging larvae. While this is a highly effective control, it also eliminates the populations of predators and parasites that prey on this pest. An alternative tactic that met with good success was to monitor the larval populations carefully to gauge when hatching was nearly complete, and then spray the trees with *Bacillus thuringiensis* Berlinger (BT) which effectively controlled the caterpillars without affecting other populations.



Spruce damage from tussock moth



The second example is the control of the ash-lilac borer (*Podesia syringae* Harns), a seasonal insect that lays its eggs in the spring on the trunks and branches of ash (*Fraxinus* sp.) and lilac (*Syringa* sp.). The larvae hatch and burrow into the sapwood eventually killing the branch or the entire tree or shrub. This particular insect hatches and lays its eggs within a very short time period in the spring. With pheromone traps it is easy to determine when the hatching has occurred; then it is time to spray. This precise knowledge of hatching and egg-laying activity necessitates only one or two pesticide sprayings as opposed to weekly sprayings over a month or more when the time of emergence could only be guessed. These three examples demonstrate the dynamic, flexible approach of the IPM concept.

Developing an IPM program for your garden will require some time, forethought, and attention to detail. An overall concern in pest control is the general health of your garden. Many insects and diseases are attracted to and able to establish themselves only in plants that are in less than optimum health. There are three generalizations concerning garden health. Proper watering is a fundamental consideration in garden health. Too much or too little water puts plants under stress. Likewise excess or inadequate fertilizer, especially nitrogen, can make plants weak and

susceptible to attack. Finally, the garden must be kept clean and tidy by proper pruning of trees and shrubs to keep dead wood cleaned out, by keeping weeds which often serve as insect and disease reservoirs in check, by cleaning out and spading under vegetable and annual flower beds and cleaning up perennial beds at seasons end to decrease overwintering sites for insects and disease.

Five interrelated steps can be identified to develop an IPM program for the home landscape: 1) Monitoring; 2) Identification; 3) Determining what are acceptable or unacceptable levels of damage; 4) Determining a control strategy; 5) Follow-up. These are not discreet steps to be followed on Saturday afternoon when you decide to see how things are going in the garden, but rather part of an on-going strategy for garden maintenance.

Monitoring

Monitoring is largely a matter of paying attention to what is going on in your garden and being knowledgeable of what ought or ought not to be going on. Get to know your garden. Take time to walk through the garden several times a week and just look. Take note of colors and color changes in leaves and flowers; look at shapes of leaves, flowers and stems. Do they look "normal", or are they twisted, cupped, or have parts missing? Occasionally turn leaves over and look into flowers. Are there bugs or signs of

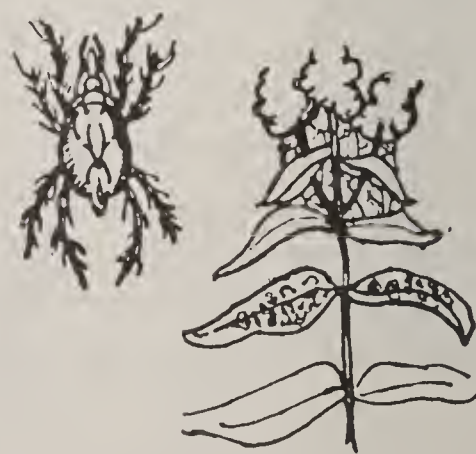
disease? Be on the lookout for changes from week to week. Are they a result of the natural course of the plant or are they signs of something of concern? Vary the time of day of your explorations.

Different insects are active and visible at different times of the day. Additionally, different light angles and intensity will make visible some things that were not easily seen at another time.

Knowledge of the insects and diseases most likely to occur, when they usually become a problem and which plants are most likely to be affected can help you be on the lookout for problems at the appropriate time. Ash-lilac borers are generally worst for a couple of weeks in early summer; tussock moth larvae are most likely to begin hatching in early spring; botrytis on peonies is worst early in the season when it is cool and wet. These are examples of pest problems that occur on a seasonal basis. Of special note here is a new service to be offered by DBG, a recorded information message (575-2547), updated each week to include notes on the appearance of insects and diseases that the Gardens will be monitoring. This can help you in your own monitoring efforts. Keep in mind, though, that a given problem may occur earlier or later at your site than at the Gardens.

Identification

Identification is perhaps the most difficult aspect of this process. There are thousands of insects and other organisms



thriving in your garden, but a relatively small number of them are harmful. Many, especially insects, are easily identified. Aphids and white flies are readily seen and recognized. But what about spider mites and the many diseases that are not readily identifiable? There are a number of sources for information. If you are a do-it-yourselfer and want to learn more about identification, Denver Botanic Gardens library has a good selection of both taxonomic and descriptive keys to aid you in your search. If you need assistance there are several sources to call or visit. The Denver Botanic Gardens has its "Dr. Green" service every Tuesday and Thursday from 1 to 3 p.m. To use this service call with your questions (575-3751) or bring them to the library. If this is not convenient, you may leave your specimen in the library and someone will call you when the identification has been made. County Extension Agents can help in identifying your problems and may be more accessible than the Gardens because there is an office in each county.

If you bring a specimen for identification, be sure it is as fresh as possible. Bring a representative sample of what the condition looks like on the entire plant. This often means bringing in a twig, stem, or small branch with both affected and healthy parts. When you cut it, seal it in a plastic bag and keep it cool. If you bring a sample or, especially, if you call for a diagnosis, be prepared to describe it in careful detail. Have a

sample in front of you when you call so that you can accurately answer the questions posed by the person trying to identify the condition sight-unseen.

Determining Damage

The third step, determining acceptable vs. unacceptable levels of damage, is difficult because it is based solely on subjective judgments. Formulae and sampling schemes are being developed for some agricultural crops but nothing exists for small scale horticulture. Here are a few guidelines to help with your determination.

While the damage caused by chewing and skeletonizing insects is visibly apparent, the problems caused by sucking insects can be more destructive though initially less visible. Harm by chewing insects is probably best assessed by rate of increase of damage. If over a period of a few days or a week the injury is clearly increasing, it is unquestionably time to act. If the damage seems not to increase significantly over time, the problem probably doesn't warrant the time and effort required to control what is possibly a few stray individuals. Keep an eye on the affected plants to be aware of changes in the future. There are some insects whose appearance is likely indication that they will indeed be a problem, e.g., Mexican bean beetle, elm leaf beetle, and tussock moth. These need to be monitored especially carefully as they are very likely to develop into major problems.



Rose curculios



Grasshoppers

The damage caused by sucking insects is two-fold. First, in large numbers, they can severely retard a plants growth and development for the season. In severe cases they may even kill the plant, especially if it was already in a weakened condition. Additionally it will be much more susceptible to disease. The second, and probably more serious aspect of sucking insect damage is that many of them transmit diseases from one plant to another. Aphids, whiteflies, and leafhoppers are among the most common sucking insects in this area.

One could argue that the presence of any sucking insects is too many. But, healthy plants will be able to withstand infection and predation up to a point. Plants are not the passive creatures we imagine them to be—they have a vast array of their own defenses. If the damage is not severe or the numbers of insects is not large, control measures other than chemical would be more appropriate. Save the chemicals, which in many cases are highly effective, for those situations that warrant their use.

Determining Control

The fourth stage of an IPM program is to decide what control measures are appropriate for the problem. If you feel that it is necessary to use control measures, do it immediately. Don't wait until the weekend after next when you think you may have time—do it tomorrow or this weekend. The insects and diseases will not wait for you. If conditions are right, they will increase and spread rapidly making control much more difficult. If you detect a problem early it may be relatively easy to control. Removal of the first virus infected pepper plant will likely prevent spread of the disease to other plants; a few days of handpicking or a forceful spray of water to dislodge insects may be all that is required to maintain populations at reasonable levels; a change in watering practices may lessen the incidence and spread of certain disease organisms or help control spider mites.

Often several techniques may be used

in concert with good results. Slugs provide a good example of the effectiveness of several tactics used together. In the vegetable garden, where most chemical slug baits cannot be used, early morning (before the sun hits the garden) handpicking can be very effective. Boards placed between the rows will serve as good daytime resting places for slugs which are then easily located and destroyed. Beer traps can be effective near a few choice plants. Slug bait may be most appropriate in a shady, moist woodland garden, as long as dogs, cats, and children can be kept out. The combination of these techniques will help control slug populations better than any one of them used alone.

Other common insect and disease problems that are best controlled by integrating several techniques are scale insects, fireblight, and grasshoppers. Scale insects often found on twigs and bark, feed by sucking, and are usually covered by a waxy coating or a hard shell. This protective layer shields them from most insecticides. Careful timing is important to control major infestations. Dormant oil is a specially formulated oil that is sprayed on deciduous trees when they are dormant and suffocates the scale insects or their overwintering eggs. The spraying is generally done in the early spring before the plants break dormancy. Read labels carefully as some deciduous and many evergreen trees are damaged by dormant oils. The other part of scale control is to spray right after the eggs hatch, before they have a chance to secrete the protective coating. At that time, they are highly vulnerable and are easily controlled with relatively non-toxic pesticides, perhaps even insecticidal soap. Check pesticide labels carefully before use to be sure that it is labeled for the insect you wish to control.

Fireblight is a common disease in this area affecting apples, hawthorn, pear, mountain ash and other members of the rose family. For the home gardener it is best controlled without the use of chemical pesticides. Use resistant varieties if you are going to add or replace

trees. Proper fertilization avoiding excess nitrogen, proper watering and not letting trees over-produce (which tends to weaken them) are all cultural controls that keep the trees healthy and help them resist infection. On infected trees remove the blighted twigs or branches 12-18 inches below the obviously affected parts, sterilizing pruning equipment *between each cut* in a 10 percent bleach solution or ethyl alcohol. There are bactericidal sprays for fireblight control but they are not practical and are of limited value for the home gardener.

Because of their large size and numbers, grasshoppers can be quite destructive. In areas of heavy infestation as vegetable or flower beds, hand picking can be very effective in reducing feeding grasshoppers. Spraying is often of limited value because grasshoppers are so mobile. A more effective method of pesticide distribution is to use baits. Spray recommended insecticide on dry wheat bran outside on a windless day and allow it to dry. Place the bait near susceptible plants. Introduction of the grasshopper pathogen *Nosema locustae* into the landscape may help with long-term control.

If you feel that pesticide use is appropriate, be sure to use the proper chemical correctly for greatest effect. This involves using the proper mixture, spraying when insects are most vulnerable, being sure that the pesticide thoroughly covers the plant; many insects live on the undersides of leaves and need to be contacted by the pesticide. Try to plan your spraying to avoid having leftover pesticide which must be disposed of. It cannot be saved until the next time and most sewage treatment facilities are not designed to treat chemical products.

Follow-up

Follow-up is really an extension of the monitoring process. As you go through

your garden, evaluate how well control techniques are working and give thought to what might be the next step if earlier efforts seem not to be sufficiently effective. Be sure to allow enough time for the control methods to work. Herbicides and some systemic insecticides will often require several days before the effects begin to show.

Integrated pest management will undoubtedly become the major approach to insect and disease control in the future. In many cases it is still easier to use a chemical control on many pests, largely because the research on alternatives has not yet been done. This is changing as botanic gardens, university horticulture programs, urban agricultural extension agents, nurseries and others begin devoting more time, money and energy to the problem. Individual gardeners can make significant contributions also. Keep track of what, when, where and how you try an IPM approach. Did it work? Why or why not? What might be done differently next time? Share your ideas and methods with your neighbors. If you have a problem that affects the entire neighborhood, try to organize control strategies over the entire area for greatest effectiveness.

Keep yourself informed. More and more will be written as the idea gains in popularity and substance. Of special note are recent editions of C.S.U. *Service in Action* sheets that approach pest control from an IPM perspective. The Denver Botanic Gardens will be publishing information as it becomes available on the integrated pest control program being developed.

Although progress is slow, eventually insects and diseases may be controlled by using few sprays and insecticides. Our gardens will be healthier and the environment cleaner through the practice of integrated pest management. ♣

Denver Grasses . . .

A Key to the Common Genera

by Janet L. Wingate

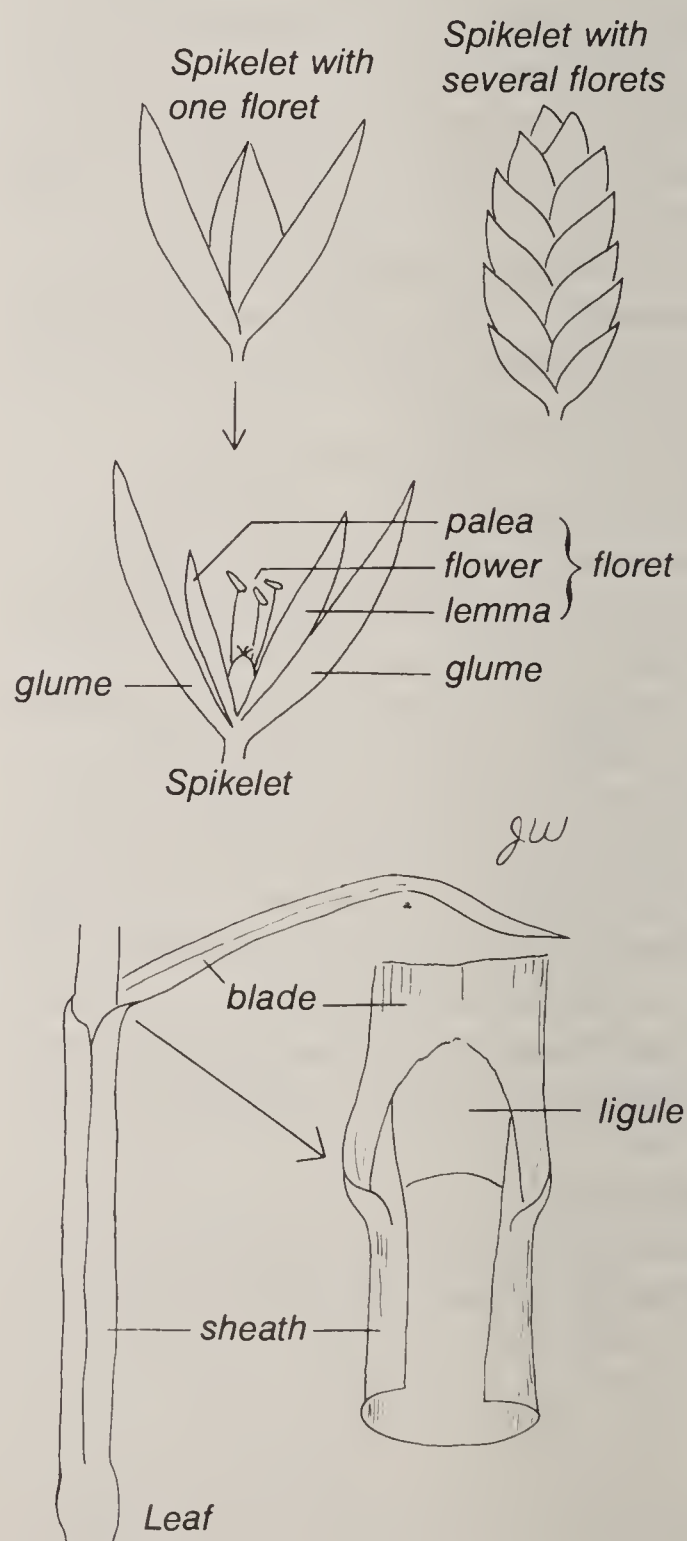
The grass family is one of the largest of all plant families and is of great economic importance to man. Such food staples as corn, rice, wheat, barley and oats are grasses. In spite of the importance of the group, most amateur botanists ignore grasses because they consider them uninteresting and too difficult to identify. Once the simple morphology is understood, however, the grasses become a fascinating group and most identifications are relatively easy.

A basic unit of grass morphology is the spikelet, which is composed of bracts and flower(s). The lowest two bracts are called glumes. Above the glumes are attached one or more florets, which are composed of a bract called the lemma, and a usually smaller bract called the palea, with the flower parts in between.

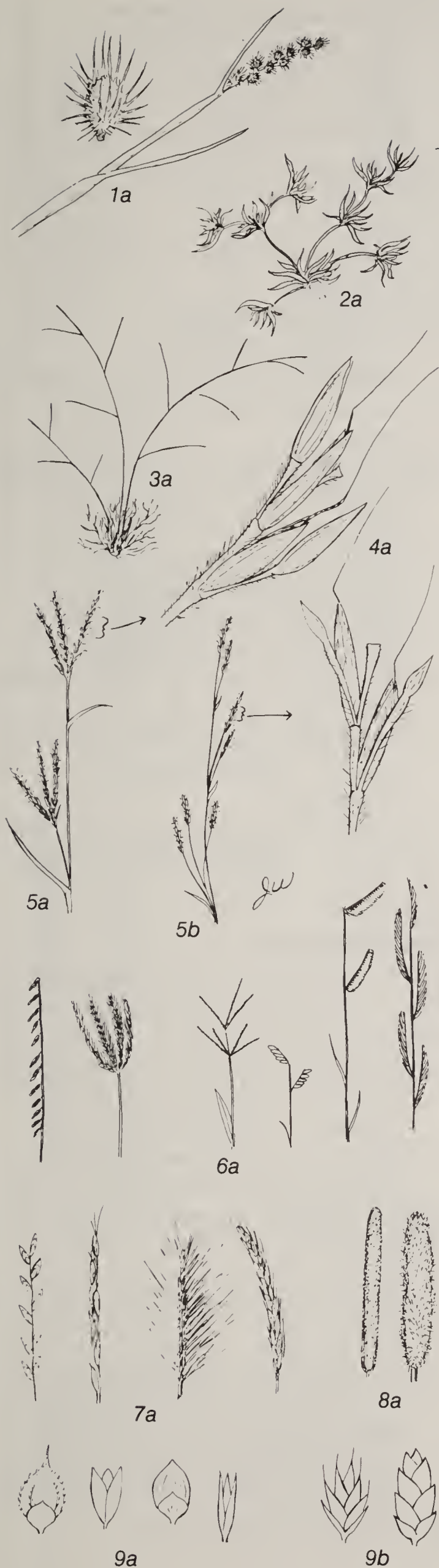
The grass leaf is composed of three parts. The lower part encloses the stem and is called the sheath. The upper part departs from the stem and is called the blade. At the junction of the sheath and blade is a small membranous or hairy appendage called the ligule.

There are over 55 genera and 110 species of native and naturalized grasses in the Denver Metropolitan area. This publication is an illustrated, introductory key to 40 of the most

common genera. A similar botanical key to the species of grasses in the Denver Metropolitan area plus simplified guides to urban, plains and Rocky Mountain grasses are available from the author.

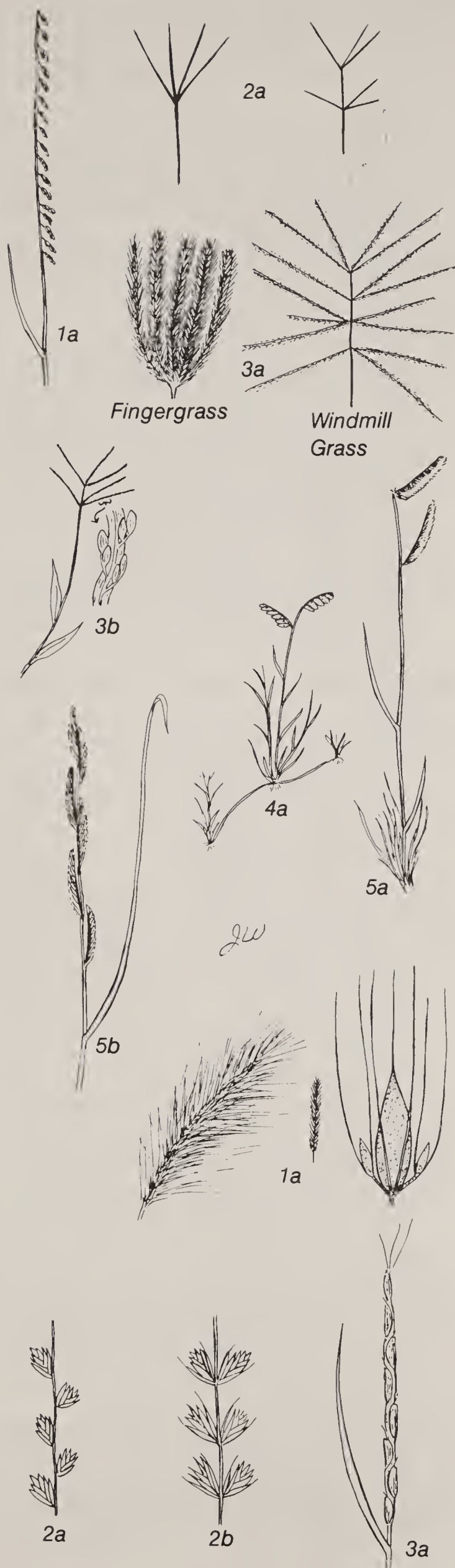


Janet L. Wingate, Ph.D., frequently combines her artistic talents and her taxonomic expertise to provide easy to use guides or keys for identifying native and naturalized plants of the region.



Key

- 1a. Spikelets enclosed in sharp spiny burs . . . SANDBUR, *Cenchrus*; annual weed of disturbed, sandy areas.
- 1b. Spikelets not as above . . . 2
- 2a. (1) Plant prostrate with spikelets hidden in tufts of short, sharp leaves . . . FALSE BUFFALOGRASS, *Munroa*; native annual of dry, open areas.
- 2b. Plant not as above . . . 3
- 3a. (2) Inflorescence composed of slender, widely spaced spikes, which spread at wide angles from curved stems; spikelets tiny, widely spaced and appressed to the rachis . . . TUMBLEGRASS, *Schedonnardus*; native perennial of dry sites.
- 3b. Inflorescence not as above . . . 4
- 4a. (3) Spikelets in pairs, 1 sessile and 1 on a pedicel; rachis and pedicel hairy . . . 5
- 4b. Spikelets, rachis and pedicel not as above . . . 6
- 5a. (4) Inflorescence \pm digitate . . . BIG BLUESTEM, *Andropogon*; native perennial of dry areas.
- 5b. Inflorescence not digitate . . . LITTLE BLUESTEM, *Schizachyrium*; native perennial.
- 6a. (4) Inflorescence composed of 1-sided spikes or racemes with spikelets sessile or subsessile on 1 side of the rachis; inflorescence appearing like one of the corresponding illustrations . . . Group 1
- 6b. Inflorescence not as above . . . 7
- 7a. (6) Inflorescence a 2-sided spike with spikelets sessile on opposite sides of a flattened rachis . . . Group 2
- 7b. Inflorescence not as above . . . 8
- 8a. (7) Inflorescence very dense and spike-like . . . Group 3
- 8b. Inflorescence not dense and spike-like . . . 9
- 9a. (8) Spikelets with 1 well developed floret . . . Group 4
- 9b. Spikelets with 2 to several well developed florets . . . Group 5



Group 1

One-Sided Spikes or Racemes

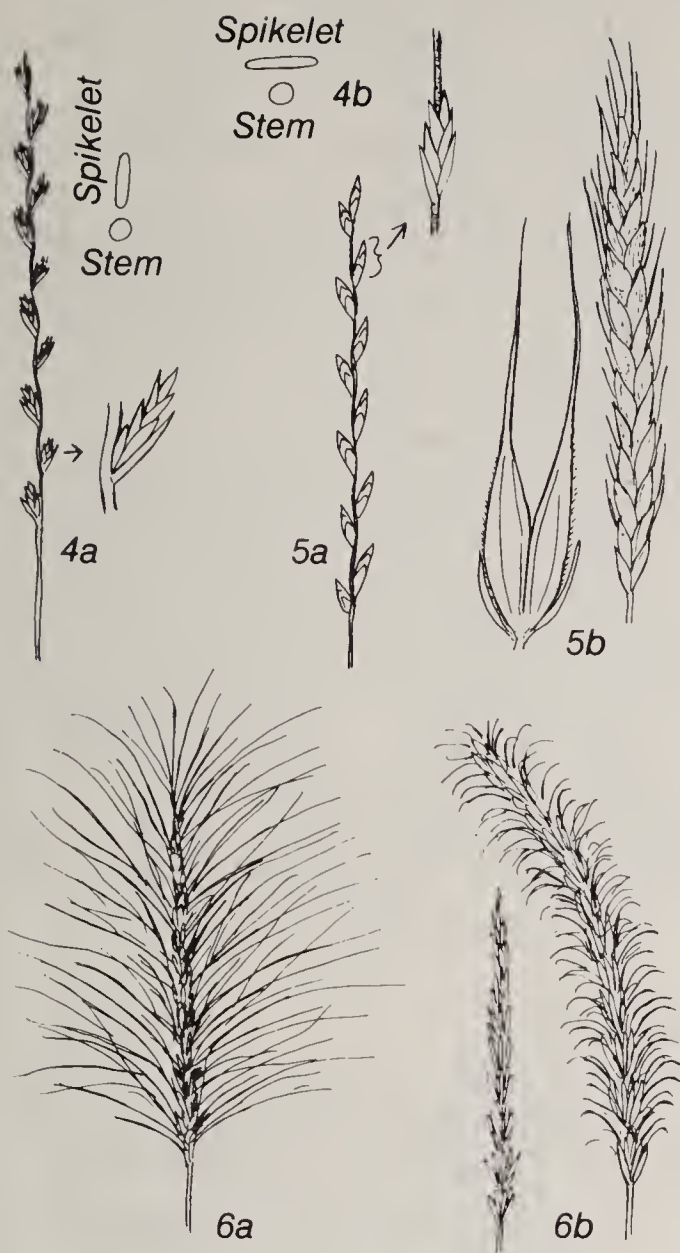
- 1a. Several small, 1-sided spikes hanging to 1 side of the stem . . . SIDE-OATS GRAMA, *Bouteloua*; native perennial.
- 1b. Inflorescence not as above . . . 2
- 2a. (1) Spikes or racemes \pm digitate, weeds . . . 3
- 2b. Spikes not digitate, native perennials . . . 4
- 3a. (2) Spikelets awned . . . WINDMILL GRASS, FINGERGRASS, *Chloris*; annual or perennial weeds of roadsides or lawns.
- 3b. Spikelets awnless . . . CRABGRASS, *Digitaria*; annual weeds of lawns and gardens.
- 4a. (2) Spike less than 1 cm long; plant usually under 15 cm tall . . . BUFFALOGRASS, *Buchloe*, sod forming grass of dry areas.
- 4b. Spike over 1 cm long; plant usually over 15 cm tall . . . 5
- 5a. (4) Plants less than 60 cm tall; dry areas . . . GRAMA GRASS, *Bouteloua*.
- 5b. Plants over 60 cm tall; moist to wet areas . . . CORDGRASS, *Spartina*.

Group 2

Two-Sided Spikes

To determine the number of spikelets per node, count the glumes—2 glumes per spikelet (except Ryegrass).

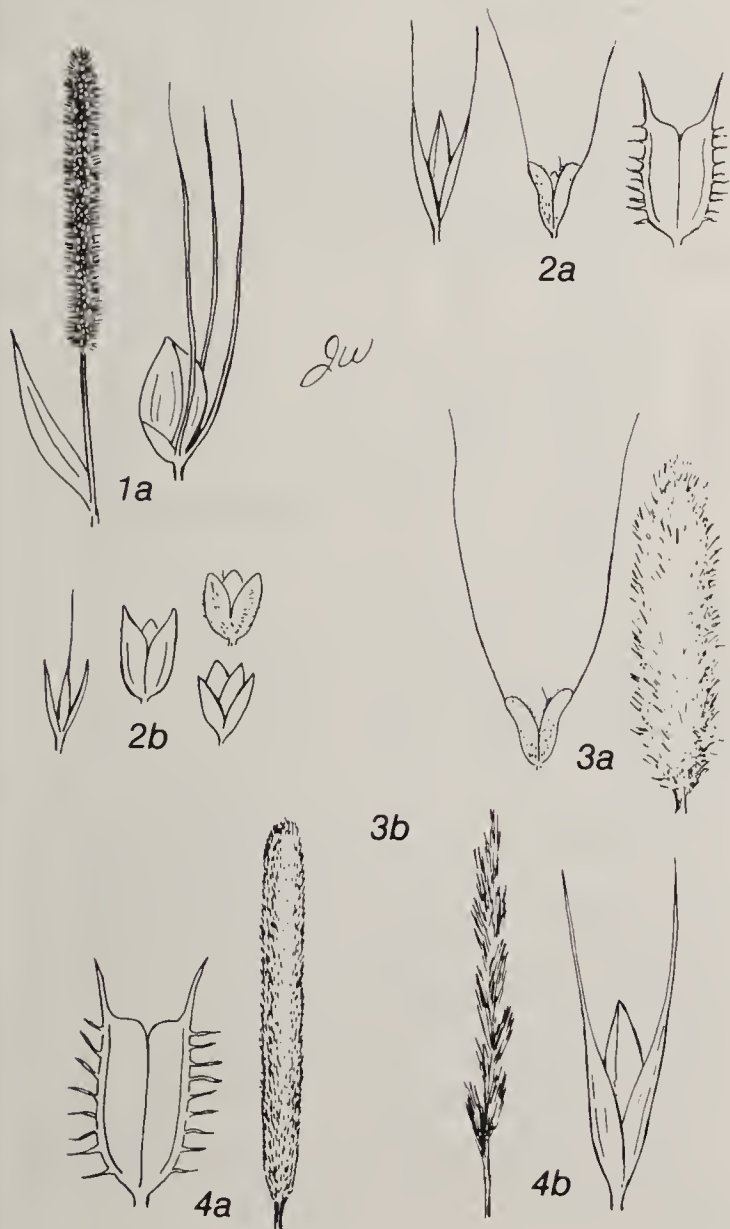
- 1a. Spikelets 3 per node; 1 central and fertile, 2 lateral, reduced and on pedicels . . . BARLEY, FOXTAIL *Hordeum*; annual and perennial grasses of dry to wet sites.
- 1b. All spikelets \pm similar . . . 2
- 2a. (1) Spikelets 1 at all or most nodes . . . 3
- 2b. Spikelets 2 or more at all or most nodes . . . 6
- 3a. (2) Spikelets recessed into the rachis, set one on top of the next to resemble the stem . . . JOINTED GOATGRASS, *Aegilops*; adventive, annual weed of dry, disturbed areas.
- 3b. Spikelets not as above . . . 4



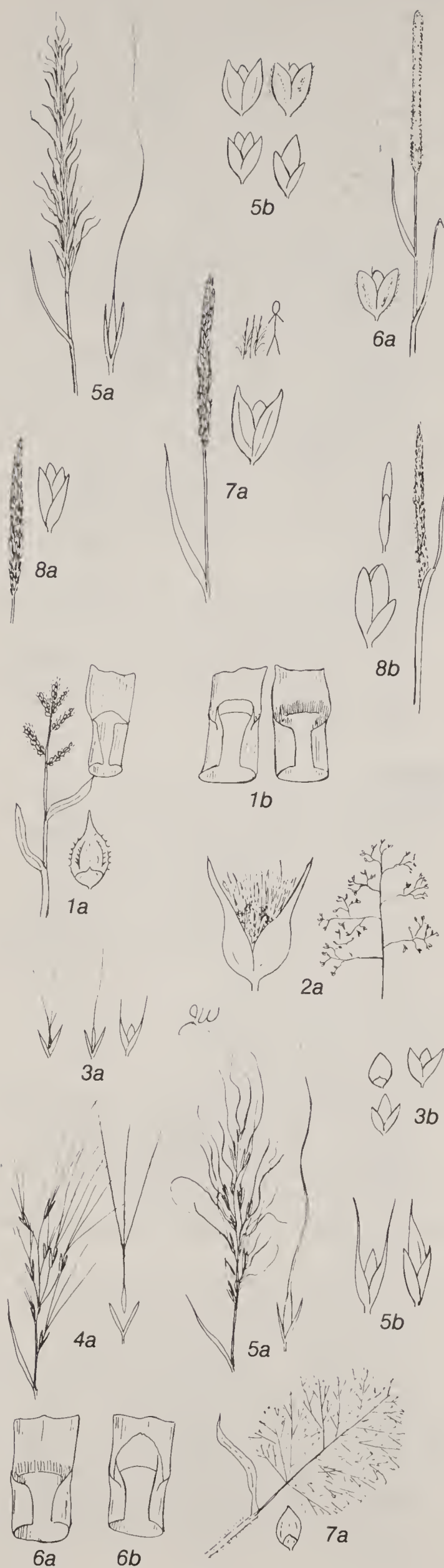
- 4a. (3) Spikelets set edgewise to the rachis with glume against rachis absent . . . RYEGRASS, *Lolium*; adventive annual or perennial of moderately moist to moist areas.
- 4b. Spikelets set flatside to the rachis with both glumes present . . . 5
- 5a. (4) Spikelets with more than 2 florets; rachis visible . . . WHEATGRASS, *Agropyron*; native and adventive perennials of dry to moderately moist sites.
- 5b. Spikelets with 2 florets; rachis hidden by spikelets . . . RYE, *Secale*; adventive annual of disturbed areas.
- 6a. (2) Spikelets mostly 2 per node; spike nearly as broad as long due to long awns . . . SQUIRRELTAIL, *Sitanion*; native perennial of dry areas.
- 6b. Spikelets 2 or more at all or most nodes; spike not as broad as long . . . WILDRYE, *Elymus*; native and adventive perennials of dry to moist sites.

Group 3

Inflorescence Dense and Spike-like



- 1a. Long bristles (not awns) attached below each awnless spikelet; inflorescence resembles a bristle bottle brush . . . BRISTLEGRASS, *Setaria*; adventive, annual weeds of disturbed areas.
- 1b. Long bristles absent . . . 2
- 2a. (1) Glumes awned . . . 3
- 2b. Glumes awnless . . . 5
- 3a. (2) Inflorescence appearing soft and furry . . . RABBITFOOT GRASS, *Polypogon*; adventive annual of moist to wet areas.
- 3b. Inflorescence appearing bristly or prickly . . . 4
- 4a. (3) Midvein of glumes with stout hairs; awns short and stout . . . TIMOTHY, *Phleum*; adventive perennial cultivated for hay, escaping and naturalized.
- 4b. Midvein of glumes not hairy; awns slender, tapering from glumes . . . MARSH MUHLY, *Muhlenbergia*; native perennial of dry to moist sites.



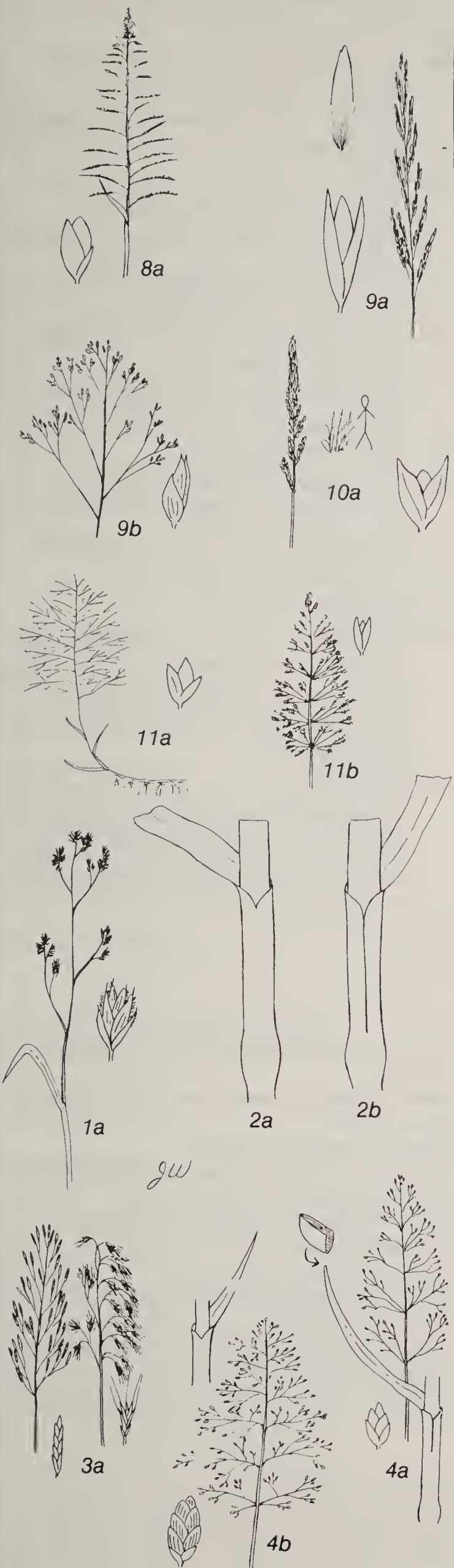
- 5a. (2) Lemma with awn over 2 cm long . . . NEEDLEGRASS, *Stipa*; native perennials of dry areas.
- 5b. Lemma awnless or short awned, less than 2.5 mm long . . . 6
- 6a. (5) Spikelets minute, about 2 mm long . . . SHORT-AWN FOXTAIL, *Alopecurus*; native perennial of moist to wet areas.
- 6b. Spikelets 4-6 mm long . . . 7
- 7a. (6) Leaf blade 6-18 mm wide . . . CANARY GRASS, *Phalaris*; tall perennial common along waterways.
- 7b. Leaf blade 1-4 mm wide . . . 8
- 8a. (7) Spikelets with 2-3 florets; plant 15-60 cm tall . . . JUNEGRASS, *Koeleria*; native perennial.
- 8b. Spikelets with 1 floret; plant 50-100 cm tall . . . TALL DROPSEED, *Sporobolus*; native perennial.

Group 4

Spikelets with

One Well Developed Floret

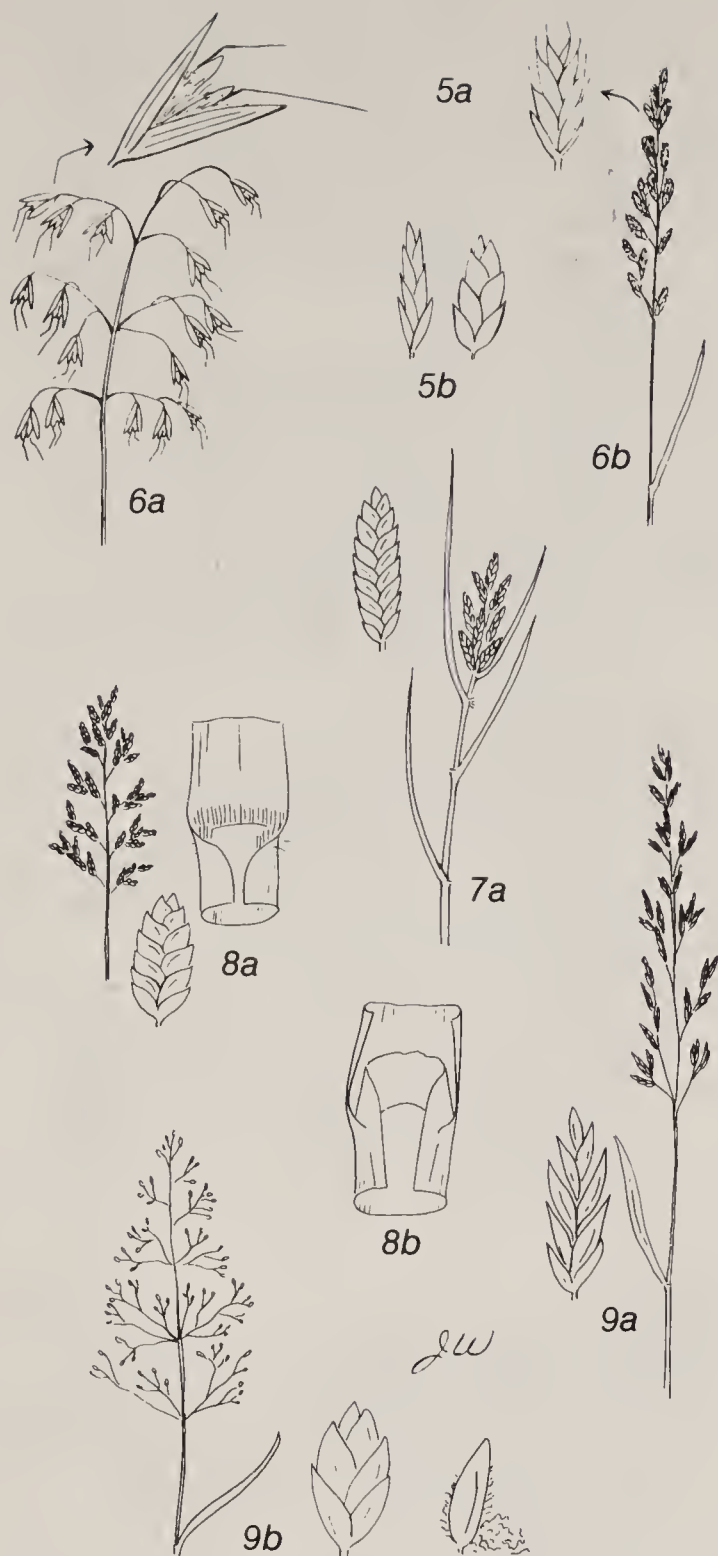
- 1a. Ligule absent . . . BARNYARD GRASS, *Echinochloa*; abundant annual weed of moderately moist to moist sites.
- 1b. Ligule present . . . 2
- 2a. (1) Lemma covered with long silky hairs . . . INDIAN RICEGRASS, *Oryzopsis*; native perennial.
- 2b. Lemma not covered with long hairs . . . 3
- 3a. (2) Awns present . . . 4.
- 3b. Awns absent . . . 6
- 4a. (3) Awns 3 parted . . . THREE-AWN, *Aristida*; native perennial of dry areas.
- 4b. Awns not parted . . . 5
- 5a. (4) Awns over 2 cm long . . . NEEDLEGRASS, *Stipa*; native perennials of dry sites.
- 5b. Awns less than 2 cm long . . . MUHLY, *Muhlenbergia*; native perennial of dry to moist sites.
- 6a. (3) Ligule composed entirely or partially of hairs . . . 7
- 6b. Ligule entirely membranous . . . 10
- 7a. (6) Sheath hairy . . . PANIC GRASS, *Panicum*; weedy annuals.
- 7b. Sheath not hairy . . . 8



- 8a. (7) Spikelets less than 3 mm long . . . DROPSEED, *Sporobolus*; native perennials of dry areas.
- 8b. Spikelets 3-9 mm long . . . 9
- 9a. (8) Floret with long hairs at base . . . SANDREED, *Calamovilfa*; native perennial of sandy soil.
- 9b. Floret without long hairs at base . . . SWITCHGRASS, *Panicum*; native perennial of moderately moist to moist sites.
- 10a. (6) Spikelets 4-6 mm long . . . REED CANARY GRASS, *Phalaris*; tall perennial common along waterways.
- 10b. Spikelets 1.5-3 mm long . . . 11
- 11a. (10) Glumes shorter than lemma . . . SCRATCHGRASS MUHLY, *Muhlenbergia*; native perennial of moist sites.
- 11b. Glumes the same length or longer than lemma . . . BENTGRASS, *Agrostis*; native and introduced perennials of moderately moist to wet areas.

Group 5
Spikelets with Two
to Several Well Developed Florets

- 1a. Spikelets in 1-sided clusters on stiff, wiry branches . . . ORCHARD GRASS, *Dactylis*; adventive perennial.
- 1b. Spikelets not as above . . . 2
- 2a. (1) Sheath closed nearly to top or at least more than $\frac{1}{2}$ of length . . . 3
- 2b. Sheath entirely open or open more than $\frac{1}{2}$ of length . . . 5
- 3a. (2) Spikelets over 10 mm long . . . BROMEGRASS, *Bromus*; annuals and perennials of dry to moderately moist sites.
- 3b. Spikelets less than 10 mm long . . . 4
- 4a. (3) Sheath closed less than $\frac{2}{3}$ length; leaf tip boat-like . . . BLUEGRASS, *Poa*; annual and perennial grasses.
- 4b. Sheath closed nearly to top; leaf tip not boat-like . . . MANNAGRASS, *Glyceria*; native perennials of wet areas.



Glossary

- Adventive** — growing spontaneously, but not native.
Awn — a slender bristle-like appendage on a glume or lemma.
Bristle — a stiff, slender appendage at the base of a spikelet.
Blade — the upper part of a leaf which diverges from the stem.
Digitate — radiating out from a central point, like spokes of a wheel or fingers of a hand.
Floret — a grass flower with lemma and palea included.
Glume — the two empty bracts at the base of a spikelet.
Inflorescence — the spikelet bearing segment of a grass plant.
Lemma — the usually larger of the 2 bracts enclosing the grass flower.
Ligule — a small appendage found at the junction of the leaf blade and sheath.

- 5a. (2) Awns present . . . 6
 5b. Awns absent . . . 7
 6a. (5) Spikelets over 1.5 cm long; glumes longer than florets . . . OATS, *Avena*; adventive annual of disturbed areas.
 6b. Spikelets less than 1.5 cm long; glumes shorter than florets . . . FESCUE, *Festuca*; native and adventive perennials of dry to moderately moist areas.
 7a. (5) Spikelets usually 6-15, large, crowded, flattened . . . SALTGRASS, *Distichlis*; native perennial of alkaline areas.
 7b. Spikelets not as above . . . 8
 8a. (7) Ligule composed of hairs . . . LOVEGRASS, STINK GRASS, *Eragrostis*; native and adventive weeds of disturbed areas.
 8b. Ligule membranous . . . 9
 9a. (8) Spikelets over 9 mm long; long cobwebby hairs never present at base of lemma . . . FESCUE, *Festuca*; adventive perennials of moderately moist sites.
 9b. Spikelets less than 9 mm long; long cobwebby hairs often present at base of lemma . . . BLUEGRASS, *Poa*; annual and perennial grasses of dry to moist areas. ♀

- Node** — the area where spikelets are attached to the rachis.
Palea — the usually smaller of the 2 bracts enclosing the grass flower.
Pedicel — the stalk of a spikelet.
Raceme — a type of inflorescence with the spikelets on short pedicels on an elongated rachis.
Rachis — the central elongated axis of an inflorescence.
Sessile — without a stalk.
Sheath — the lower portion of the grass leaf which surrounds the stem.
Spike — a type of inflorescence with the spikelets sessile on an elongated rachis.
Spikelet — 1 or more florets enclosed by 2 glumes.



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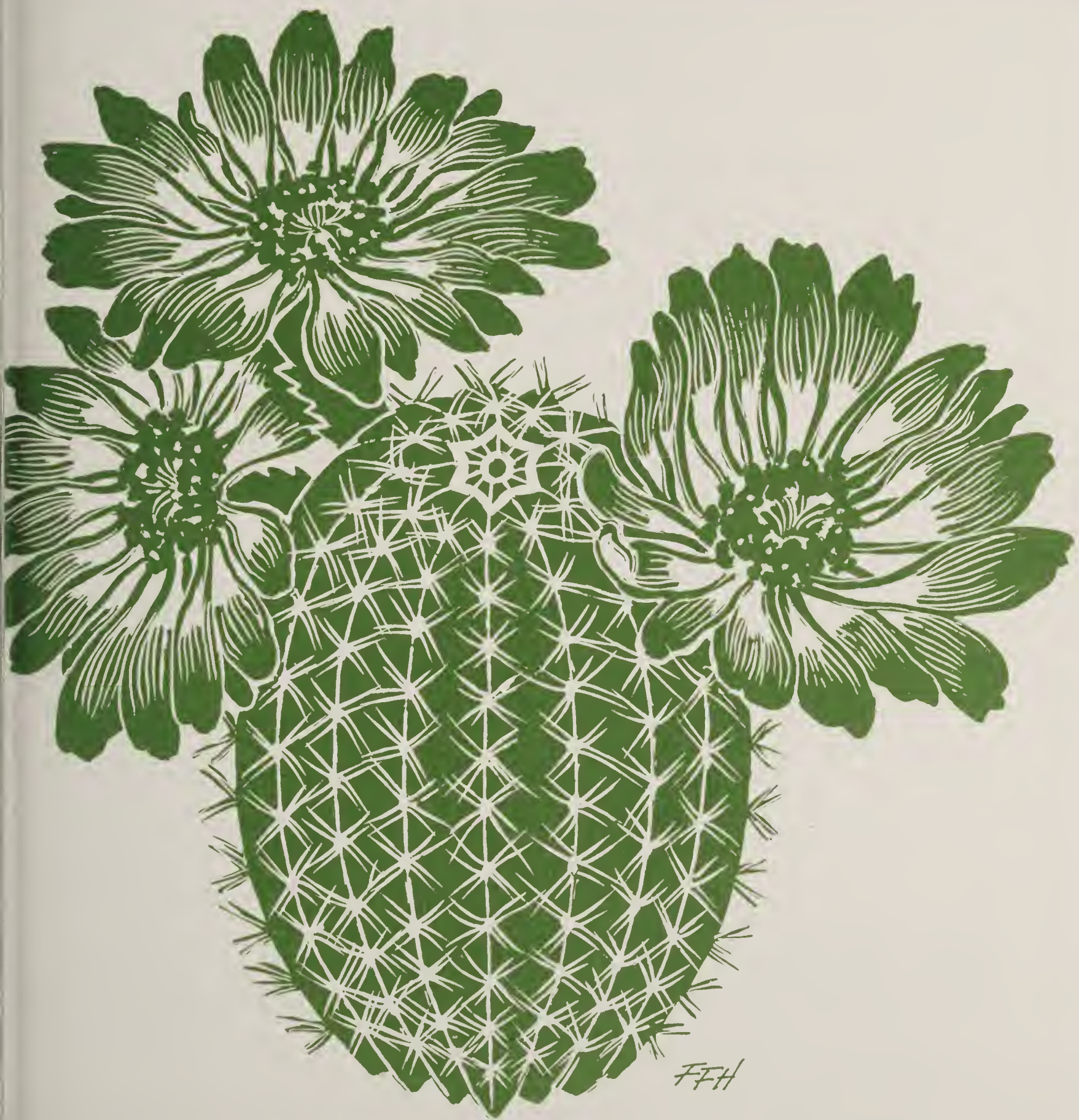
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Number Two



The Cover

Cactus

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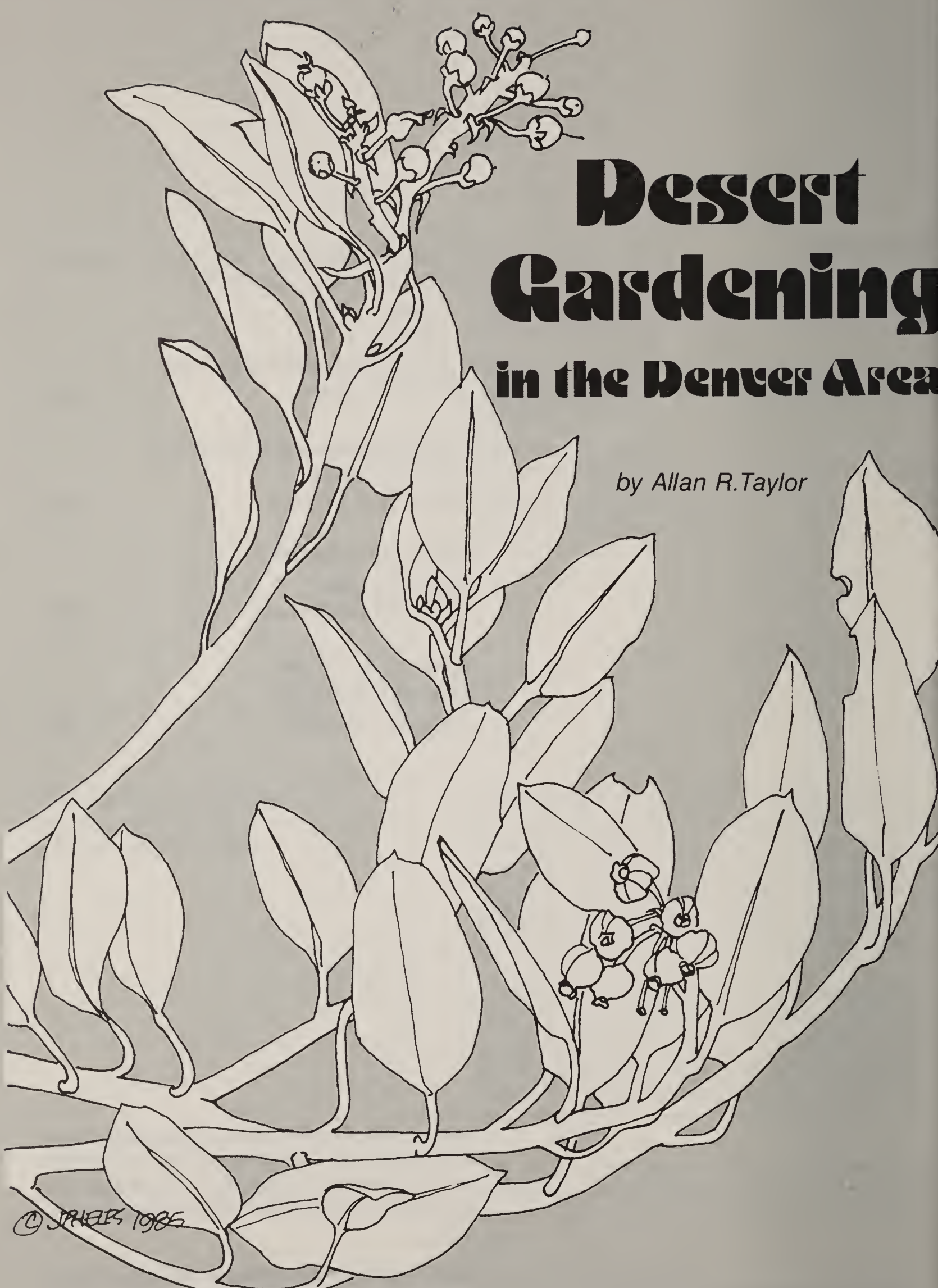
Velma A. Richards
Editor

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Desert Gardening in the Denver Area

by Allan R. Taylor

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Desert, or dryland, gardens are a natural choice for an arid or semiarid area. The issue is not so much water savings—though that must be a consideration when the water supply is either chronically short or certain to become so—but rather atmospheric humidity: plants adapted to dry air do best in dry air. Irrigation can supply moisture if needed for the root zone, but supplying a moist atmosphere under the open sky is much more difficult. An additional, esthetic, consideration is that the garden should be a microcosm of some sort; what better landscape can a gardener emulate than the regional landscape which surrounds the garden?

Arid gardens, then, are in many ways ideal for our area where water ought to be conserved whenever possible, and where there is a wealth of plant material already selected for our conditions. In this article I shall share my philosophy and experience in dryland gardening.

My major philosophical premise is that my garden will include only American native plants, which, if they do not all occur together naturally in the same habitat, at least occupy similar or closely neighboring habitats.

A dryland garden in Colorado should be populated by plants that demand, or at least tolerate, drought; it will not be watered but will have to survive and, hopefully, thrive on natural rainfall. Drought tolerance can range from slight to full. In an arid garden we should take cognizance of this both in construction and in the plant material eventually chosen.

Successful dryland gardening in our area, where the precipitation is about 15 inches annually, must employ strategies to combat soil humidity, which in some parts of the year can be very high. Not only is there the problem of concentrated moisture adequate for unwanted oppor-

tunistic weeds; there is also the problem that so much moisture per year, particularly in the winter resting period, is far too much for some very desirable desert plants.

Planning the dryland garden

A dryland garden must be carefully laid out to provide for rapid, almost total drainage and/or evaporation of soil moisture. This can be accomplished by a combination of three factors: exposure, incline, and soil structure.

Ideal exposures, to the south or the west, provide maximum sunshine and heat in all seasons. Many desert plants require brilliant light and considerable heat during their growing season if their appearance is to be maximally attractive. In winter they need heat to clear away snow as quickly as possible. Other exposures are not impossible, however; my arid garden, for example, faces north, because no other site was available to me. The less than desirable exposure has to be compensated for in other ways.

Incline refers to unevenness of elevation. There is little place for a level surface in an arid garden, just as there are few such places in nature. What we find in nature, rather, is a medley of slopes and inclines, all the work ultimately of tectonic processes such as erosion, elevation and subsidence. By providing slopes and avoiding basins in the garden, we achieve rapid drainage, and possibly create exposures different from that of the garden as a whole, thereby providing microclimates for plants which otherwise might be impossible to grow.

The desirable uneven surface is obtained by mounding up, preferably starting at the original surface; the slopes are stabilized exactly as in nature, by large rocks, pebble mulches and, eventually, anchor plants. A compromise must be found between steepness and too rapid runoff; the goal should be to accomplish swift drainage without erosion. Both experience and the eye are the guides; a slope which is too steep to survive under natural conditions must not be created. The angles that we see in undisturbed

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land will create the kind of natural appearance we seek, as well as a surface form of reasonable stability.

The last strategy which the arid gardener employs to combat humidity is soil structure. The soil should be loose to a depth of at least 2 feet. This is easiest to achieve by mounding on the original surface, since sand and fine gravel can be incorporated into the soil easily before it is contoured. It is not a bad idea, however, to plow or otherwise work into the soil of the site as much grit as possible, even before contouring. (The amount of sand and rock chips to be incorporated varies according to the nature of the original soil: a heavy clay requires a mixture of at least 90% sand or chips. Looser original soils require less.) Hard work at the beginning provides for later success; omitting soil preparation, on the other hand, guarantees the loss of plants and also ultimately excludes many.

Plant placement should be done with great care if the plants are to do well and the desired esthetic effect is to be achieved. When planting, it is important to keep in mind the needs of each species: does it require full sun, or does it do best in part shade? Does it grow naturally below a rock, or above, or possibly neither? Equally important, what will the garden look like after planting? What will it look like in ten years? Plant placement should always be done with such things in mind as height and spread of the plant at maturity, blooming season, and the size and color of foliage and flowers. These are serious issues in a garden, since far more varieties are combined there ordinarily than in nature, which seldom must accommodate a large number of disparate characters. Nature can only correct our ill-advised decisions by removing the plant; she cannot move it to a better or a more appropriate place. Gardeners should never forget that the thoughtlessly planted garden is a mere collection, a motley hodge-podge, possibly a grotesque horror, while the carefully planted garden can be a serene work of art.

An abundance of native plant material

is available for the desert garden in our area, due both to our dry climate and to the close proximity of desert and very dry lands around us. Plants from arid areas both north and south, if not too far, do about equally well here; and these can be added to the large number of drought tolerant plants native to our area.

Sources of plants

Since the number of such plants is extensive, I shall list by families and genera whenever possible, pointing out only particularly desirable species and varieties. The aspiring arid gardener should spend some time researching the groups indicated in order to select the particular plants for his/her garden. Some research will also be necessary to discover commercial sources for the plants. Several nurseries in the Front Range area offer native plants, but species offerings vary from season to season.

Direct collection of plant material from its native habitat by a knowledgeable person is probably the best source for native plants. This may sometimes be inappropriate, however, since collection of seeds, cuttings or plants may be prohibited. Collection of plant material is expressly prohibited, e.g., on federal and state lands, and several states have laws restricting collecting native plant materials. Be sure to check with the proper authorities, including private property owners, before attempting to collect seed or other plant materials from the wild.

Consideration must also be given to the effect such collecting may have on the ecology of the natural site: Is there great enough abundance to ensure that collecting will not affect the site adversely? Will taking cuttings be injurious to the plant, or will its vigor, on the other hand, be enhanced?

A number of companies, mostly small, one-person businesses, have the needed permits and specialize in the collection of wild seed or other plant material for propagation. While the offerings of such companies may be restricted and vary from year to year, much good material can be obtained through them. Probably

the best current sources of information on such suppliers are friends or correspondents with whom you have a common plant-specialty interest or the catalog collection of a club or institution. The Denver Botanic Gardens library has a good selection of specialty catalogs, as well as lists of organizations and agencies that can supply species plant materials. A good way to get to know the broad variety of existing sources is to check there.



Dr. Taylor's Desert Garden

Trees



Juniperus osteosperma, Utah Juniper

Conifers

In larger arid gardens, one or more trees contribute greatly to the natural appearance of the garden and provide desirable focal points. The trees *par excellence* for an arid planting in our area are pinyon pines (*Pinus cembroides* Zucc., varieties *edulis* Engelm. and *monophylla* Torr. & Frem.) and members of the juniper race. Of the latter I recommend *Juniperus osteosperma* (Torr.) Little, Utah juniper, *J. monosperma* (Engelm.) Sarg., one-seed juniper, and the very beautiful *J. deppeana* Steud., the alligator juniper. Not native to Colorado, this juniper exists in forms hardy enough for our area, though insufficient testing has been done to say which are good sources for it. In this case, and in others mentioned below, experience accumulated by local gardeners could ultimately be of great value to

the nursery trade. Also possible are *J. scopulorum* Sarg., Rocky Mountain juniper, and *J. virginiana* L., red cedar, though their growth habit is frequently somewhat too formal for a naturalistic planting, particularly one which features plants which usually exhibit a rugged appearance.

Another conifer of great potential interest is *Cupressus arizonica* Greene var. *glabra* (Sudworth) Little. Although it is conventional wisdom that none of the cypresses are hardy enough for our area, preliminary testing over the past eight years has shown that some individuals of both *C. arizonica* and *C. bakeri* Jepson, Modoc cypress, are fully hardy here. In Boulder several of each survived -30°F during December, 1983, without damage. Only time will tell whether cold tolerance is the only crucial variable.

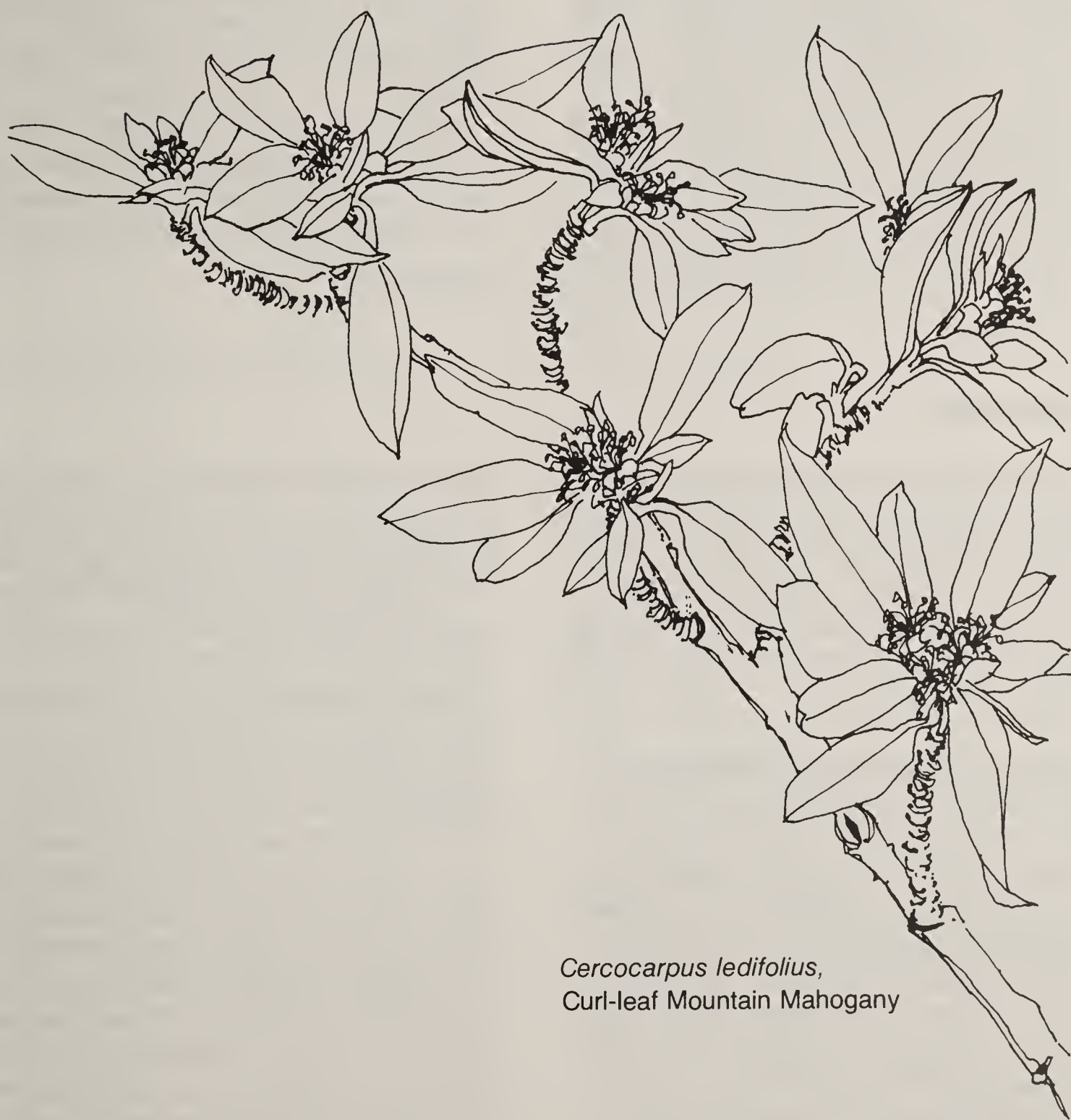
Broad-leafed evergreens

Another pair of handsome small evergreen trees—in this case broad-leafed—are *Cercocarpus ledifolius*, Nutt. ex Torr. & Gray, mountain mahogany, and its close but more tender relative, *Cercocarpus betuloides* Nutt. ex Torr. & Gray, birch-leafed mountain mahogany. *C. ledifolius* is native to the Great Basin and high altitude areas in surrounding states. A slow-growing member of the rose family, it favors extremely dry sites. In great age it looks at a short distance much like an ancient pinyon pine or juniper. *C. betuloides* is even more handsome, but it has not been sufficiently grown in our conditions to be counted as of certain success. Continued exploration will certainly provide adequate forms.

Deciduous desert trees

A deciduous desert native, *Chilopsis linearis* (Cav.) Sweet, desert willow, is sufficiently hardy for our area if the seed source is at the northern edge of its natural habitat (Albuquerque area, Las Vegas, Nevada area). Several established individuals of this taxon survived our bitter cold in December, 1983, without appreciable damage.

Other desirable small trees are *Prosopis juliflora* (Sw.) DC., mesquite, and *Robinia neomexicana* Gray, southwestern locust; both are legumes, of which many adorn the deserts of the world. As with desert willow, mesquite for our area must be from as northern a source as possible, e.g. the Oklahoma Panhandle. The plant is very susceptible



Cercocarpus ledifolius,
Curl-leaf Mountain Mahogany

(2) JHEP 1985

to frost damage. *Robinia neomexicana*, a tree of the southwestern uplands, appears to be fully hardy under our conditions. It possesses one possibly undesirable characteristic: it is thicket forming, producing suckers freely from the base of the trunk and from the roots. All three of these deciduous trees are very desirable for an arid garden, both because of their growth habit and because of their splendid flowers; in the mesquite, these appear in spring, and are pale to medium yellow. Southwestern locust has pale pink to rose colored showy flowers in early summer. Blooming in June, desert willow has flowers which range from pink to lavender, though in some cases the color approaches that of the whitish flowers of its near relative, the catalpa.

Two small native trees of the oleaster family offer stunning silver-gray foliage. These are *Shepherdia argentea* (Pursh) Nutt., buffalo berry, and *S. rotundifolia* Parry. (Note that their close relative, *Elaeagnus angustifolia* L., Russian olive, though widely naturalized throughout arid western North America, is actually a Eurasian native, as its common name implies. It is very drought tolerant, how-

ever, and is a fine subject for an arid garden which includes material from all parts of the world.) The deciduous leaves of *S. argentea*, a native of the northern Great Plains, are long and narrow. The evergreen leaves of *S. rotundifolia* are roundish (hence the name) and metallic in appearance. This striking plant can be viewed in a beautiful rimrock setting in Zion National Park, though its distribution is much wider. *S. argentea* is very hardy in the Denver area. *S. rotundifolia* may be much more tender, and further testing needs to be done with material from different areas before we can regard it as completely dependable here. It grows near Green River, Utah, however, and likely possesses sufficient hardiness for our area. Whether it can withstand heavy winter snow is another matter.

Another small deciduous tree, single leaf ash, *Fraxinus anomala* Torr. in the olive family, is native to the Colorado Plateau in the Four Corners area. This shrubby, drought tolerant tree does not look like an ash in that it does not have a compound leaf; its leaf actually looks more like that of a cottonwood or an aspen.

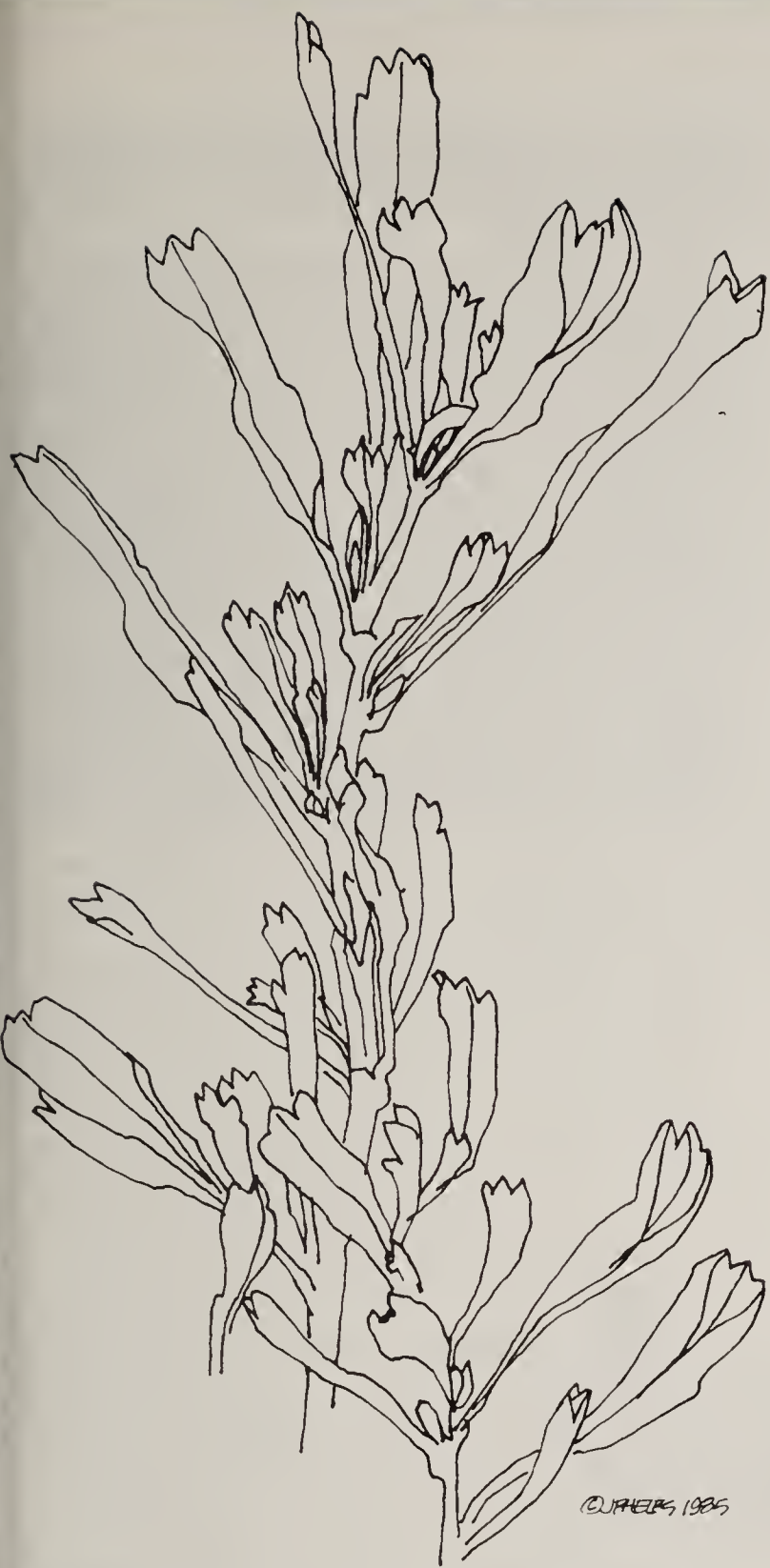
Shrubs

In this group are woody plants which may range from virtually arborescent to low, twiggy bushes. The boundaries are arbitrary and certainly subjective. Also, growth conditions can transform a large shrub into a small one, or a large shrub into a small tree.

Sages and other gray-hued plants

Probably the quintessential shrubs of cold American deserts are the sages. Three of these which must certainly be in a desert garden are *Artemisia tridentata* Nutt., big sagebrush, which can grow under favorable conditions as high as 12 feet, *A. ludoviciana* Nutt., prairie sage, lower growing and very wooly, and *A. spinescens* D.C. Eat., bud sagebrush, a low spiny plant producing small,

chamomile-like yellow flowers in early spring. What seem to be dwarf forms of *A. tridentata* occur in several high, cold, very arid locations around the West, e.g. the Red Desert of Wyoming and the Colorado Plateau. These forms (most have actually been established as independent taxa) look very much like *A. tridentata*, but are less than a foot in height. One, *A. pedatifida* Nutt., forms a mat barely 2 inches high. These sages are of extremely easy culture, as are the sages in general. One very handsome herbaceous sage deserving mention is *A. frigida* Willd., fringed sage. Native in our area, as well as generally all over the West, from foothills to very high elevations, it is low growing, intensely silver, and very downy in appearance. It self-sows pro-



Artemisia tridentata, Big Sagebrush

fusely, so it is fortunate that it is such a beautiful plant.

A number of other composites also lend character to the desert landscape by their blue-gray color. Typical are *Chrysothamnus nauseosus* (Pallas) Britt., rabbit brush, which occurs in a large number of forms, from waist high to dwarf, and the closely related *Gutierrezia* species, snakeweeds. All of these composites seed freely, and some seedlings may have to be eliminated from time to time.

Also known as sages but of the mint family are the salvias, several of which, e.g. *Salvia dorrii* (Kellogg) Abrams, purple sage, are very attractive. Much experimentation remains to be done in our area with this interesting genus, many of whose species are of unknown hardiness

for our conditions.

Somewhat similar to the sages in appearance, and popularly classed with them, are many members of the goosefoot family. Typical is the *Atriplex* complex; several are native to Colorado and are readily available from dealers in native plants. Especially attractive in fruit is *Atriplex canescens* (Pursh) Nutt., four-wing salt-bush, with thread-like whitish-green leaves and clusters of large silver-green seed prominently displayed in late summer. Two other members of the goosefoot family deserving inclusion in an arid planting are *Grayia spinosa* (Hook) Moq., hop sage, and *Ceratoides lanata* (Pursh) J. T. Howell, winter fat. Both are native throughout cold, dry regions of the West and are completely hardy in Colorado.

Two handsome shrubs in the gray-colored group are *Elaeagnus commutata* Bernh. ex Rydb., silverberry, and *Forestiera neomexicana* Gray, New Mexico privet. Both are deciduous; silverberry suckers rather freely, a characteristic which some might find objectionable. Some individuals have broad leaves almost metallic in aspect and the berries on the female plants are also an intense, metallic silver. The name is well merited. New Mexico privet has blue-black fruits which resemble small olives.

Rosaceous shrubs for arid gardens

Several American members of the genus *Prunus* are adapted to arid habitats, e.g. *Prunus fasciculata* (Torr.) Gray, desert almond, *P. andersonii* Gray, desert peach, and *P. fremontii* S. Wats, desert apricot. All are native to the southern Great Basin and the Mohave and Colorado Deserts. *P. fasciculata* is growing successfully in private plantings in the Denver area and at Denver Botanic Gardens. Both desert peach and desert apricot should be tested in our region. *P. andersonii*, especially, is a handsome shrub with beautiful pink flowers, and it is quite likely sufficiently winter hardy here. *P. fasciculata* has small white flowers early in spring, followed by a crop of tiny fuzzy fruits. It might well not crop

often in our area due to late spring frosts. The plant can also be damaged severely when very young by heavy snow; as it gets larger, however, it seems to shed the snow more successfully. In maturity it has whip-like branches with very narrow leaves and is well worth the effort required to get it to this stage.

Another attractive member of the rose family is the small shrub *Coleogyne ramosissima* Torr., blackbrush. This low, thorny, very hardy plant is quite beautiful because of its growth habit and reduced leaves. Its flowers, on the other hand, are inconspicuous. It is heavily

browsed in habitat by deer and rabbits, a process which probably greatly improves its appearance.

Six other members of the rose family, all evergreen, are archetypical of the cold portions of our western deserts. Least like the others are *Chamaebatiaria millefolium* (Torr.) Maxim, fernbush, and *Petrophytum caespitosum* (Nutt.) Rydb., rock spirea. Fernbush, native in Arizona north of the Grand Canyon and in the Great Basin, has yarrow-like evergreen leaves and showy, spirea-like fragrant white flowers. Rock spirea, a mat-forming under shrub, occurs throughout much



Fallugia paradoxa, Apache Plume

of the West at higher altitudes. The white flowers on spikes appear during the last half of the summer.

Throughout the Colorado Plateau and the Great Basin, and in dry areas even farther north (e.g. the Bitterroot Valley of Montana), also occurs *Purshia tridentata* (Pursh) DC., bitterbrush, a chest-high evergreen bush with tiny-toothed, cuneate leaves. *Cowania mexicana* D. Don, cliffrose, looks very much like bitterbrush, and the two are known to hybridize where they occur together. Both have strawberry-like, pale yellow to white flowers typical of the primitive roses. The fruits' long, spiral tails eventually waft the seeds to a resting place at some distance from the parent plant. *Falugia paradoxa* (D. Don) Endl., Apache plume, is the southernmost of these rosaceous shrubs, and it, too, has the prominent tailed fruits that have given the plant its common name.

The sixth member of this group is *Cercocarpus intricatus* S. Wats., a dwarf mountain mahogany which should be planted more often. It is a neat, twiggy shrub, especially when browsed by deer or sheared by the gardener. In common with the other mountain mahoganies, it has petalless, inconspicuous flowers and tailed fruits in late summer.

These latter six rosaceous shrubs are well known in dryland gardens in our area, and all may be regarded as certain to be successful in new plantings.

Manzanitas

A relatively large number of broad-leaved evergreen or semi-evergreen shrubs are desert natives and of great drought and considerable cold tolerance. My favorites among these—by a great deal—are the manzanitas of the heath family, and related to such unlikely plants from the point of view of tolerance of aridity as rhododendrons and blueberries.

Manzanitas are largely Mexican in distribution, although many species also occur in southern California. Four, however, extend up from the south or cross the Sierra Nevada into territories where cold winters prevail. Two of these reach

the high Uncompahgre Plateau of southwestern Colorado, an area of intensely cold winters with heavy snows. These are the mat-forming *Arctostaphylos nevadensis* Gray, quite similar in appearance to our alpine native bearberry, and *A. patula* Greene, greenleaf manzanita. This exceedingly handsome evergreen plant occurs along the West Coast, in the Sierra, and sporadically all around the Great Basin, from a relict population in western Montana to the Mogollon Rim in northern Arizona. Excellent, large stands of it can be seen in Zion National Park near its eastern, higher edge, where individuals are sometimes 15 feet or more in height. The Colorado native forms, however, are scarcely waist high. With its mahogany-red stems revealed by the shedding bark typical of the manzanitas, its broad, stiff, bright green leaves and deep pink flowers, this arbutus-like shrub is certainly one of the most beautiful flowering plants of the entire world.

Somewhat similar to the greenleaf manzanita, occurring in high altitude areas slightly further south, is *A. pringlei* Parry. Pringle's manzanita reaches a height of 8 feet, even in cold areas. The leaves in this taxon are more oval in shape and neither so stiff nor so green. The color of the exposed stems is more nearly orange, and the plant is generally more compact than *A. patula*. Experimental planting of this shrub has only begun in our area, so it is far too soon to say whether it is suitable here, as the Colorado native manzanitas described above certainly are.

Also still in the preliminary stage of testing here is *A. pungens* H.B.K., the pointed-leaf manzanita. It varies from knee to waist high and ranges from bright to ashen green in color. Forms from the upper Oak Creek Canyon (north-central Arizona) survive here without difficulty, but they sustain considerable frost damage to exposed leaves and branch tips. Forms from other areas, e.g. the Virgin Mountains of northwestern Arizona, may do better. Time and further testing will tell.



Quercus turbinella, Shrub Live Oak

Oaks

Several dwarf desert oaks are evergreen or semi-evergreen and worthy subjects for planting in a desert garden. Unquestionably, the best of these is *Quercus turbinella* Greene, the shrub live oak. The tiny, holly-like evergreen leaves are usually a steel blue color. Depending on growing conditions, this delightful oak is a much branched shrub 3-4 feet high to a small tree 25 or more feet high. *Q. turbinella* is beginning to be appreciated now outside of its natural habitat in the desert Southwest, both as a cultivar and as a source of evergreen and dwarf genes in oak hybridization programs. For example, an extremely handsome hybrid has been made between *Q. turbinella* and the valley oak of California, *Q. lobata*

Nec. Through this hybrid, which is very interesting in its own right, cold areas now have access to some of the attractive characters of the valley oak, chiefly its elegant, long, ivory-colored acorns. *Q. turbinella* is undoubtedly present in stable hybrid populations of very ancient lineage in the southern part of our own state. Some individuals of this complex, which has been designated *Q. undulata* Torr., are very difficult to distinguish from *Q. turbinella* during the growing season, both in color and form. Autumn, however, reveals the difference: *Q. undulata* is deciduous. Experimentation here with hardy desert oaks is just beginning, and it is certainly one of the most challenging and promising areas for future arid gardening in our area.

Barberries

Berberids are a prominent part of the desert flora in the Great Basin, the Colorado Plateau, and the Mexican deserts, and their striking evergreen (in one case everblue) foliage is nearly as attractive as their typical, brilliant yellow flowers. Three deserve special mention, though one of these is as yet problematic for our area. Certainly hardy and well tested are *Berberis fremontii* Torr. and *B. haematocarpa* Woot. The latter is unbelievably beautiful. It has a compound leaf with rounded leaflets which are typically a turquoise or lapis lazuli blue. Growing head high, it blooms heavily with the expected yellow flowers of the genus, followed by large, garnet-red fruits which hang like lanterns along the upright stems. *B. fremontii* is less striking—its compound leaf is green, the leaflets more pointed—and looks much more like the familiar shrub mahonias. Large, apricot-colored fruits are probably its most attractive feature. Both of these shrubs can be sheared (they are heavily browsed in their native habitats), and very old plants develop a heavy basal trunk.

The largely tender species for our area is an endemic of the Chihuahua Desert; visitors to Carlsbad Caverns National Park may recall having seen it there. *B. trifoliolata* Moric. is a low (knee to waist high) shrub with a tripartite, sagittate, very leathery compound evergreen leaf. It often serves as a nurse plant for *Opuntia leptocaulis* DC. or other cactus seedlings. *O. leptocaulis* is wont to hide unnoticed in the clasp of the barberry, until the bright red fruits of the cactus betray its presence. Extensive testing of clones of this plant from its northern limit (the Texas Panhandle) may discover sufficiently hardy forms for our area, an outcome greatly to be wished, given the striking beauty of the plant.

Ephedra or jointfir

Another typical endemic of the pinyon pine-juniper desert is *Ephedra*, Mormon tea or jointfir. This distant relative of the pine family consists of jointed branches

which carry on photosynthesis, as do the needles in pines. In cold climates such as ours, the ephedras are bushy but not particularly tall, usually not much higher than the waist or shoulders. *E. viridis* Covilla, found throughout the Great Basin and the Colorado Plateau, is a bright green shrub, as its name implies. Other handsome and perfectly hardy ephedras are *E. nevadensis* S. Wats., found throughout the western portion of the Basin and southward, and *E. torreyana* S. Wats., occurring in the southern Great Basin, the Colorado Plateau, and the Chihuahua Desert. Neither of the latter two are commonly grown in Denver, but both will undoubtedly prove hardy here. The most beautiful ephedra, *E. californica* S. Wats., which is a soft pearly blue color, will probably prove to be too tender for the Front Range of the Rocky Mountains.



Ephedra viridis, Green Ephedra

Pea family

Leguminous shrubs also figure prominently in desert landscapes, particularly those in subtropical latitudes. Fortunately, some shrubby legumes also occur in cold deserts. One such is *Dalea formosa* Torr., feather dalea, native in both the Sonoran and Chihuahuan deserts. Plants from the northern edge of the latter (e.g. Santa Fe, New Mexico) would probably do well in the Denver area. This plant has

handsome magenta flowers. *D. fremontii* Torr., indigo bush, with blue flowers, might also succeed here, as it occurs as far north as Zion National Park.

The treatment given shrubs here is admittedly very cursory; this is a rich area, and probably my greatest interest in desert gardening. A would-be dryland gardener is admonished to research possible sources to add other drought-tolerant shrubs to the nucleus provided here.

Succulents and Sclerophylls

Succulent plants share a particular physiological character: water storage. Native western plants included here are the agaves and the cacti with their succulent leaves or stems. Sclerophyllous lilies suitable for our arid gardens are the yuccas and their close relatives; all have a woody stem base or caudex and hard, fibrous leaves.

Yuccas

Who has not seen *Yucca glauca* Nutt. ex Fraser, that ubiquitous Great Plains native found on rocky hillsides and overgrazed pastures? This plant is certainly reliable and virtually care-free in the Denver area. Yuccas come in all sizes, from the giant Joshua tree, *Yucca brevifolia* Engelm., of the Mojave Desert to tiny dwarf forms scarcely five inches in height. All, when mature, produce annually a spike of cream-colored bells which, if pollinated through the efforts of the yucca's indispensable partner, the female pronuba moth, are followed by fat ornamental pods. Only a few are hardy to -20°F which must be assumed for the Denver area. The dwarf form of the Joshua tree, *Y. brevifolia* var. *jaegeriana* McKelvey—still 28 to 25 feet tall at maturity—would probably be hardy here, since it is found at 7,000 feet in the Charleston Mountains of southern Nevada, but the variety still requires much testing. In the event of successful cultivation in our gardens, it will probably be more dwarfed, even under favor-

able growing conditions. In a desert planting near Ogden, Utah, is an impressive specimen, which, after many years, is barely 8 feet tall.

Several other yuccas are completely reliable in the Denver area. *Y. elata* Engelm., the state flower of New Mexico, with its short, stout trunk is particularly beautiful because of the marginal fibers which produce a silver web toward the center of its rosette of sabre-like leaves. Another handsome and popular yucca in this area is *Y. baccata* Torr., the banana or datil yucca. This plant is common on the Western Slope from the extreme west of Mesa County south, but the most beautiful form is var. *vespertina* McKelvey, native in the area north of the Grand Canyon where Utah, Nevada, and Arizona meet. It is a striking steel blue color; the Colorado form is dark green.

Two other yuccas are worth mention. *Y. harrimaniae* Trel., common in the Colorado Plateau of Utah and western Colorado, is one of the most beautiful of the hardy yuccas. Its rosette is flattish, the leaves wide and blunt, the color a light green. In age, this plant produces a low, thick, much branched trunk. A possible variant occurring farther east in Colorado is a low (10 inches), sharp plant which produces a short spike of flowers barely clearing the leaf rosette.

Probably my favorite yucca is an as yet unidentified plant (quite likely a hybrid, since it seems never to set seed) that grows in the area of the La Sal Moun-



Yucca baccata, Banana or Datil Yucca

tains. I have seen the plant in habitat south of Moab, Utah, and in the Dolores River Valley in western Mesa County, Colorado. It spreads by underground runners which send periodic shoots to the surface. The rosette of stiff, sharp leaves with whitish edges is about 6 inches across and 4 inches high and has a halo of threadlets around its center.

Other liliaceous plants suitable for the arid garden are the nolinias or beargrass, notably *Nolina texana* S. Wats., native from southeastern Colorado south, and the sotols, e.g. *Dasyllirion wheeleri* S. Wats. The sotols, while very desirable, require considerable additional testing before they can be counted a regular part of our arid plant palette. Also worth growing, if a protected microclimate exists in the garden, is the so-called red yucca, *Hesperaloe parviflora* (Torr.) Coulter. This plant, native in a restricted area in south Texas and northern Mexico,

stands a chance of success in Colorado only in very dry, very coarse soil which does not freeze in the winter. I have yet to succeed with it, though some others in the Denver area have.

Agaves

The century plants or agaves, like the yuccas, have their center of distribution in Mexico. Only a few are hardy enough for our area.

Two large species, both quite beautiful, occur in the high, cold areas of northern Arizona. *Agave parryi* Engelm. exists in very hardy forms, and numerous plants of the species are growing in the Denver area. To be successful, this agave should come from sources as far north as possible, e.g. above the Mogollon Rim in the Flagstaff, Arizona area. Possibly also hardy is *A. mckelveyana* Gentry, a mountain form similar to *A. desertii* En-



gelm. This agave has narrower leaves than *A. parryi*. in which the leaves are broad, blue, and tipped by a sharp, black point. *A. toumeyana* Trel. var. *bella* Breitung from the Sierra Ancha of central Arizona also does well in our area. This handsome plant with white-edged, short, narrow leaves is a dwarf (about 5 inches across and 5 inches high) which, in age, forms a colony of heads.

Another quite hardy agave is the *A. utahensis* Engelm. complex, which occurs from the Kaibab Plateau north and west of the Charleston Mountains in southern Nevada. *A. utahensis* is a clump former with dentate leaves that curve up and in rather than open and out. A single head is typically about 8 inches wide, though clumps may be larger. Each flower emerges directly from the long bloom stalk giving a spray or wand-like look to the inflorescence. The handsomest of the complex is var. *eborispina* (Hester) Breitung, which occurs only in the Charleston Mountains. Individual heads in this form can measure almost a foot across, and the curved leaves are tipped with elongate, ivory-white spines.

A very different sort of agave, *Agave lechuguilla* Torr., occurs in the Chihuahuan desert; it is quite common in the area of Carlsbad Caverns National Park. Light green in color, it is also a clump former, with each head being tall and slender rather than low and fat, as is the case with other clump-forming agaves. The bases of the leaves are often marked by dark colored stripes. I have not yet succeeded with the lechuguilla, but I am hopeful that a very hardy clone will eventually be discovered.

Whether any of these agaves will flower here is unknown. It requires many growing seasons to produce a flowering stalk, hence the common name, century plants. Since we are well beyond the normal limit for these beautiful plants, perhaps we will have to be satisfied with rather dwarfed, non-blooming specimens. Many of the agaves die after flowering, so I am not at all anxious to have mine flower: I am happy to settle for the plant alone!

Cacti

The classical American succulent plant is the cactus. Although tropical in origin, certain genera of the family have adapted to the temperate regions of both North and South America. Cacti are native only to the Americas; some form is native in each of the U.S. states except Hawaii, Alaska, Maine, New Hampshire and Vermont. The many cacti found in Hawaii are all introduced.

Cacti are certainly a likely element in a western arid garden. Most are attractive the year round, but almost all are spectacular during their flowering season in the spring and early summer months. Many are hardy here, although temperature is less a limiting factor than soil moisture and the weight of snow. Provision of very porous soil can solve the wetness problem in part, as can planting on slopes and among rocks. The problem of snow weight, on the other hand, can only be solved by selecting plants which are naturally very low, or which have adapted to heavy snow.

Prickly pears

Two principal kinds of cacti in terms of their growth form are ball or barrel-shaped forms, and jointed forms. The hardy jointed forms all belong to the genus *Opuntia*, prickly pears and chollas. These come in arborescent, as well as clump-forming varieties. Prickly pears are available in an almost infinite variety of flower colors, spination, and plant and pad color and size.

The greatest success is achieved, I have found, with prickly pears from the Great Plains or from the Great Basin and the Colorado Plateau, including Colorado's Western Slope. Plains forms are often yellow flowered, although I have one from Cheyenne County, Colorado, which is a spectacular dark rose in color. Western Slope forms tend to be pink or red flowered. Most of these are *O. polyacantha* Haw. As their specific name suggests, they are fiercely armed with long, white, and in some cases, brown spines. *O. phaeacantha* Engelm. can also

be grown, but less successfully because the plant does not dehydrate in the fall, with the result that it suffers considerable breakage from snow. *O. phaeacantha* is actually a large complex (as are most of the "species" suggested for the cacti), with many varieties, some of which become head high. Forms taller than two or three joints are of questionable use here, even if cold tolerant enough, simply because snow devastates them.

Another handsome complex is the group designated *O. violacea* Engelm. As the name implies, this group has considerable purple pigmentation in the pads. The color is strongly accentuated when in bright sunlight, or when either very dry or very cold. The spines, which occur (if at all) only along the upper margin of the pad, are also a deep purple. The flowers of this group are a rather uninteresting yellow; an exception is variety *macrocentra* (Engelm.) L. Benson in which the yellow flowers have brilliant red centers. None of this complex is very cold hardy, so the gardener who plants them must expect to lose plants rather regularly.

Another complex which is quite successful here is *O. basilaris* Engelm. & Bigelow, beaver tail cactus. This Mojave Desert native comes in a large variety of forms, all characterized by quite naked pads. All are clump formers. In some, the pads are long and narrow, in others, round or very blunt. Some forms also have numerous fine bristles (glochids). The flowers, ranging from dark rose, almost red, through pink, to yellow and white, are among the most spectacular of the genus. Some produce both pink and yellow flowers on the same plant.

The last prickly pear complex that I recommend is *O. erinacea* Engelm. & Bigelow, also a Great Basin species. The famous "Grizzly Bear" cactus of California belongs to this group. While cold hardy, this cactus cannot tolerate wetness. My plants regularly lose their roots in winter. Some plants of this complex have long, hairlike spines; others have only marginal spination. The flowers of this group tend to be pale pink.



Opuntia basilaris aurea, Bever Tail Cactus

Chollas

The cylindrical forms of the genus, called chollas, are shrubby or even arborescent. Most suitable for gardens here is without doubt *O. imbricata* Haw., native from Colorado Springs south to central Mexico in the Chihuahuan Desert. It grows head-high but can bear the weight of our heavy spring snows once it is established. Some forms produce an abundance of satiny, pinkish-purple flowers.

The Mojave Desert has several chollas worth growing, though my success with them has been less than with *O. imbricata*. *O. acanthocarpa* Engelm. & Bigelow grows quite tall, and looks very different from *O. imbricata*. *O. echinocarpa* Engelm. & Bigelow, the silver or golden cholla, from the highly colored spine sheaths, is spectacular in its native habitat. It is unfortunately brittle, and always suffers frost damage here. The flowers in both of these Mojave natives are not particularly interesting.

Another shrubby Mojave native, *O. ramosissima* Engelm, though not yet well tested in our area, seems to be sufficiently hardy but is subject to snow damage. I am currently testing a mat-forming variety

of this cactus found high in the Charleston Mountains, several thousand feet above where it is supposed to occur. In addition to its very unusual mat-forming habit, it is quite naked, and of a pinkish-purple color. It looks like a very promising plant.

Two other chollas which grow well in our area are *O. kleiniae* DC. and *O. leptocaulis* DC. Both of these produce long branches. *O. kleiniae* grows in thickets in the southern Great Plains, where it is native. *O. leptocaulis* is the "Christmas Cactus" of the Mexican deserts, so called

because of the brilliant red fruits which adorn the plant in winter. Both of these chollas have their slender branches broken by heavy snow. I have succeeded with both only by planting them close in under *O. imbricata*, which shelters them and gives them support. In fact, they clamber all over their sturdy cousin when given the protection they need.

Within the chollas there is an interesting group which has short, club-like branches and broad, flat spines. One of these, *O. clavata* Engelm., native to the northern Rio Grande Valley near Albuquerque, New Mexico, is very hardy and often planted because of its truly bizarre appearance. In time it forms large, low clumps of knobby, fiercely armed heads. Its flower is yellow, and very typical of the opuntias, though it seldom flowers, even in nature.

Ball and barrel cacti

Of ball or barrel cacti Colorado has several native genera, and most are easily grown in a desert garden. The most spectacular is the *Echinocereus* complex. For gardening purposes it is perhaps best to divide this group by either flower color or by colony versus solitary plant growth habit.

The hardiest of the colony formers is *E. triglochidiatus* Engelm. This complex is characterized by its scarlet flowers shaped like a badminton birdie. A colony of this plant with many score heads in full bloom is a sight never to be forgotten. Three distinct varieties are native to Colorado. On the Western Slope and along the southern tier of counties on the Eastern Slope is variety *coccineus* Engelm. In the Cañon City vicinity generally is variety *gonacanthus* (Engelm. & Bigelow) L. Benson. This is my favorite form, due to the deep red color and large flower size which it exhibits. Also on the Western Slope occurs variety *melanacanthus* (Engelm.) L. Benson, which appears in all degrees of spination from full to entirely naked. All of these do well in an arid garden, and all are relatively easy to obtain through commercial sources.



Opuntia imbricata, Walking-stick Cholla

Other very desirable *Echinocerei* occur as solitary plants, or in clumps of two or three heads. These can be divided into magenta-flowered and yellow-flowered sorts. Desirable species in the magenta-flowered group occur only marginally in Colorado, but many are perfectly winter hardy here. Notable are *E. reichenbachii* (Terscheck) Haage, f., ex Britton & Rose, lace cactus, which occurs from southeastern Colorado south to Texas; *E. fendleri* Engelm., purple torch, from New Mexico and Arizona; and *E. engelmannii* Parry, occurring in the Mojave Desert and north of the Colorado River in Arizona. This plant is hardy in our area if it winters over in absolutely dry state.

The yellow-flowered group includes fewer members; reliably hardy is only our lovely, diminutive native *E. viridiflorus* Engelm. This plant is abundant on uncultivated hilltops in the Denver area. Larger, closely related forms occur throughout New Mexico; some are conventionally segregated under different varietal names, e.g. *E. viridiflorus* var. *cylindricus* (Engelm.) Engelm. ex Ruml.

Another beautiful genus of hardy ball cacti is *Coryphantha*. This genus, together with another, *Neobesseya*, is closely related to the mammilarias, and are classed as *Mammilaria* by some taxonomists. *Coryphantha vivipara* (Nutt.) Britt. & Rose is one of the showiest of the



cacti when in flower. Fortunately it is bone hardy (its northern limit is in southern Saskatchewan!). This cactus produces huge colonies, hence the name *vivipara*; the flowers, which come at the apex, vary from light to dark pink. There are a number of other coryphanthas native to the Great Basin and to the states to the south of us, all exceedingly beautiful in both flower and spination, but none are as reliably hardy as *C. vivipara*. *Neobesseya missouriensis* (Sweet) Britt. & Rose, also a colony-former, has straw-colored flowers followed a year later by showy, bright red fruits. Its large, southern plains form, *N. similis* Britt. & Rose, is even more handsome and fully hardy in

the Denver area. All of the Great Plains natives are very much at home in grass, and because of this, are often unnoticed until they flower.

Still another ball cactus with several forms native to Colorado is *Pediocactus*. *P. simpsoni* occurs both in the foothills of the Front Range and high into the montane zone, where it nestles in the duff under pine trees. Mountain forms are black spined, but a beautiful white-spined form is found in the foothills. The earliest cactus to bloom, it has pale pink to deep rose flowers which appear at the growing center on top of the plant. In a sheltered, south-facing location it can bloom as early as March; some plants



smother themselves in flowers.

Several species of *Pediocactus* and the closely related genus *Sclerocactus* are native in the Great Basin and on the Colorado Plateau. Most of these are difficult to grow in the Denver area because of our wet winters and springs. I have lost many plants, and I do not encourage a gardener to attempt these species unless they are given a great deal of attention.

Cactus propagation

Before leaving the cacti, I wish to make a point about their propagation. Due to their extreme specialization, they are not easy to transplant. (The cacti are more subject to crown rot than any other plant I know.) After a cactus has been dug, it must be allowed to dry thoroughly before it is replanted. This is because broken roots, if not callused, permit entry into the plant of soil bacteria which quickly kill it. After the plant has dried—at least two weeks in summer, longer in other seasons—it can be replanted, but it should not be watered even then. (Re-

member that the plant's body is almost entirely stored water, which it will draw on to reestablish itself.) From the time the plant is removed from the soil until it is replanted, it should be protected from sunburn; but it should not be held in low light either, since it will then sunburn when it is replanted.

The prickly pears are best propagated by cuttings, which is easily done when the plants are growing (roughly July-September). A pad (or pads), or a section from a cylindrical species, is cut off the parent plant and allowed to dry thoroughly. The same strictures mentioned above apply to cuttings. After the cut surface has dried, the pad can be laid on the ground where it is to grow and it will root from the surface in contact with the soil. No watering is necessary. The cut end of the pad can also be buried in the soil, with the pad upright, and rooting will occur wherever the soil contacts the surface of the pad. I cannot emphasize too much that transplants or cuttings can not tolerate water until all breaks in the skin have healed.



"Desert Gardening in the Denver Area: Part II" will appear in the autumn 1985 issue of *The Green Thumb*. It will include herbaceous plants, both perennial and annual, suitable for a dryland garden.

— Editor

Plant Strategies for Survival on Little Water

by James H. Richards

Plants that require less water than typical landscape plants can be beautiful and at the same time conserve water. Many of these plants are selected from the broad range of native species which survive in our mountains, deserts or plains with no irrigation except that received naturally. The mechanisms that allow them to survive with little water provide a fascinating glimpse of the diversity of function in plants.

When plants live on infrequent irrigation or only on natural rainfall and soil water, they are subjected to a much greater degree of water stress than that experienced by typical landscape and garden plants. Water stress develops in the green tissues of these plants when there is an imbalance between the rate of water uptake and the rate of water loss from leaves and/or green stems. Thus, bluegrass lawns exhibit symptoms of stress when water uptake is limited by dry soils. Conversely, some moisture and shade-loving flower species like primroses and columbines may show wilting responses under bright and warm conditions even though the soil remains quite moist. In this second case, the imbalance which has led to stress is because water loss rates are greater than water uptake rates.

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The development of water stress can occur over different periods of time. It may occur within a day as when plants wilt in the middle of the day and recover later in the afternoon. Water stress can also develop over longer periods such as several days, weeks or even whole growing seasons.

Stomatal control of water loss and carbon gain

In order to understand the mechanisms of plant response to developing water stress, the interactions between water loss and carbon gain need to be understood. Often much of the damage by water stress may be secondary due to the lack of a plant's ability to continue to photosynthesize. Photosynthesis occurs when plants take up carbon dioxide from the atmosphere and make sugars and other organic compounds from it. Carbon dioxide can only be taken up from the atmosphere when the plant's stomata, or pores on the leaves, are open. As a necessary consequence of the open stomata, plants lose water. Thus there is a very tight linkage between water loss and carbon gain in all plants.

A plant under water stress can reduce its rate of water loss by closing the stomata to some extent but this also results in a reduced rate of photosynthesis. Most plants are not capable of keeping their stomata completely closed for long periods of time because they then can no longer manufacture their required

food resources through photosynthesis. Even with totally closed stomata, plants tend to lose some water through the cuticle, the waxy covering on the leaf.

Escaping water stress

The response of stomata of different types of plants illustrates some of the strategies plants can use to survive water stress when little water is available or when there is a large imbalance in uptake versus water loss. In some plants, such as cacti and other succulents like sedum, a specialized type of photosynthetic metabolism allows plants to take up carbon dioxide through open stomatal pores at night when the rate of water loss is very low due to cooler and more humid conditions. In these plants the stomatal pores are totally closed during the daytime thus significantly reducing the rate of water loss when conditions are most adverse. Many of these plants also have cuticles which are impermeable to water so that the rate of water loss when the stomata are closed is also extremely low. These plants exhibit maximum stomatal closure during the daytime and thus suffer relatively minor dehydration of their tissues. Essentially they escape water stress. However, because of their particular photosynthetic physiology, known as crassulacean acid metabolism (CAM), they are usually very slow-growing plants.

Avoiding water stress

A second type of response is exhibited by plants which have intermediate degrees of stomatal closure. These plants suffer low to moderate levels of tissue dehydration and often are capable of very rapid growth when water is available. The stomata of these plants are extremely sensitive to low humidity conditions and begin to close when exposed to dry air. This mechanism reduces the rate of water loss during the middle portions of the day or under warm conditions and thus postpones the development of stress by attempting to balance the rate of water loss to the rate of water uptake. Most vegetable garden

plants, crop plants and many plants used in landscaping that have been derived from plants native to more humid climates exhibit this type of response.

After a period of several days to weeks of this kind of stomatal closure during the middle of the day, the water available in the root zone of the plant may be depleted to such an extent that recovery in the evening is impossible. At this point these plants will suffer total stomatal closure and undergo a starvation condition. The mid-day stomatal closure exhibited by these plants thus acts to postpone dehydration of their tissues. In this way they are able to avoid the development of water stress to some extent but do not really tolerate it.

Tolerating water stress

A third type of stomatal response is exhibited by plants which are more tolerant of water stress. Stomata on these plants usually show less sensitivity to dry warm air and have relatively small amounts of stomatal closure. Since the stomata remain open for longer periods of time and under drier atmospheric conditions, the leaves of these plants tend to suffer rather severe levels of dehydration. However, since the stomata are capable of remaining open, photosynthesis and other metabolic processes can continue, although usually at reduced rates. These tolerator plants have intermediate growth rates when water is available. They are able to withstand long periods without much water in the rooting zone because they can maintain some photosynthetic uptake of carbon dioxide which enters through the partially opened stomata. Many of the plants which have light or moderate water requirements are within this category and include kinnikinnick, blue fescue, blue grama, and junipers and curl-leaf mountain mahogany.

This series of examples illustrates a range of plant responses to water stress. While such plants may be considered escapers, avoiders or tolerators, these are not discrete categories but rather a spectrum or continuum from plants

which escape water stress to those which tolerate it. The response of stomata to developing stress and atmospheric humidity is only one of the characteristics which determines whether a plant should be considered an escaper or a tolerator. Escaping water stress requires a combination of characteristics including rapid stomatal closure, specialized photosynthetic physiology, thick cuticle, and tolerance of high temperatures. Likewise, the tolerance strategy requires a combination of physiological and morphological characteristics which can assure the survival of a plant under high degrees of water stress. Perhaps the ultimate tolerators are mosses, lichens and some ferns which can withstand more tissue dehydration than that

tolerated by most higher plants. The spectrum of strategies of plant survival in the face of water stress is indeed broad.

Some of the other physiological and morphological characteristics of plants which allow them to survive water stress might be associated with only one type of plant, i.e., an escaper, while others might be associated with plants exhibiting a range of strategies for survival under water stress conditions.

Maintaining water uptake

One of the most obvious characteristics needed to increase water uptake and therefore reduce the development of stress would be a deep root system. Many plants which are tolerators of water stress allocate a very high proportion of their resources to root systems versus



Demonstration xeriscape garden of the Denver Water Department
Foreground: *Penstemon pinnifolius*; Midground: *Santolina* sp. and *Yucca glauca*; Background: *Rhus trilobata*.

shoot systems. While in humid or high rainfall situations only 20 to 40% of the biomass may be in root systems belowground, in many semi-arid and arid environments as much as 90% of the total plant biomass may be belowground.

A physiological mechanism called osmotic adjustment appears important in allowing plants to maintain the root pressure required for continued root growth even under dry soil conditions. Continued root growth allows the plant to maintain some water uptake by assuring that some roots are in soil zones where water is still available. Obviously, plants which have specialized root systems with very deep taproots or even some grasses which have deeply penetrating roots would be capable of maintaining water uptake for long periods of time by having access to a large soil volume.

Some plants, called phreatophytes, which have very deep tap root systems could be considered escapers. In contrast to cacti which escape water stress by CAM, phreatophytes are able to maintain a favorable water balance in their tissues not by reducing water loss rates but by maintaining high rates of water uptake under all conditions. This is possible because their deep roots penetrate the soil to the water table. Usually phreatophytes only occur where the water table is relatively shallow, such as along washes and stream courses. Phreatophytes certainly do not conserve water, but rather utilize very large quantities of it.

Reducing water loss rate

There are many mechanisms which plants use to reduce the rates of water loss. Already mentioned are the importance of stomatal closure and impermeable cuticles to prevent water loss from leaf tissues. Both cacti and true water stress tolerators have these characteristics, but to different extents. When tolerators have reduced rates of water loss due to partial stomatal closure evaporative cooling of their leaves is also reduced. Unless other mechanisms are present to reduce overheating, they may

then be damaged by high temperatures. Thus, plants which have the capability of reducing water loss rates to very low levels often will have corresponding characteristics that will prevent leaf overheating. Some of these characteristics include: small or deeply dissected leaves, light-colored pubescent or waxy coatings, and leaf movements. All of these characteristics can contribute to keeping the leaf cool in the absence of any evaporative cooling. In addition to avoiding heat damage cooler leaves lose water at lower rates. Small or deeply dissected leaves remain closer to air temperature than large leaves because they more effectively transfer any heat they have absorbed to air around them. Leaves which have light-colored pubescent or waxy coatings on them absorb less radiation (light) and thus are subjected to lower heat loads. And finally, many plants exhibit leaf movements, or in grasses, leaf rolling, which reduces the surface area exposed to the direct rays of the sun.

Another way which plants can reduce the rate of water loss from their tissues is to reduce the surface area of leaves by being drought deciduous. Leaf shedding often occurs as the growing season progresses and water stress conditions become more prevalent. Sagebrush is a plant which exhibits partial drought deciduousness. It loses its large spring-produced leaves late in the summer but maintains smaller summer leaves throughout the dry part of the growing season.

Maintaining photosynthetic activity

Many of the physiological characteristics of tolerator plants are more important for maintaining some photosynthetic activity than for reducing the rate of water loss. The maintenance of photosynthetic activity, however, allows metabolism to continue and thus is a mechanism of water stress tolerance. The most important physiological characteristic of these plants is their ability to exhibit osmotic adjustment in their leaf tissues. This process,

mentioned before for root systems of tolerant plants, is an active accumulation of organic compounds such as sugars, or inorganic compounds such as potassium ions. Osmotic adjustment occurs in response to exposure to mild to moderate water stress.

The main result of osmotic adjustment is maintenance of turgor. When plant leaves lose turgor they wilt. Thus, plants which are capable of osmotic adjustment can maintain turgor which is required for continued growth and for stomatal opening. Partial stomatal opening allows photosynthesis to continue producing energy sources for repair of damage, replacement of enzymes and other cellular components, for transport of compounds within the plant, and for continued root growth to maintain some water uptake.

Occurring alone, any of the mechanisms described would not be adequate to confer water stress tolerance or escape on a plant. Thus the strategies for survival require a combination of a

number of mechanisms within the plant. Water stress tolerators like mountain mahogany or junipers have relatively small leaves, thick cuticles, exhibit some degree of stomatal closure but are able to maintain photosynthesis and continue root growth because of good osmotic adjustment. Because of these characteristics they are capable of surviving on low amounts of water for long periods of time. This is what makes them so useful in xeriscape landscaping.

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EXOTICS OF COLORADO

Osage Orange, *Maclura pomifera*

by Helen Marsh Zeiner

Osage orange, *Maclura pomifera* (Rafinesque) Schneider is an interesting tree seldom seen in the Denver area. However, if you go to Denver Botanic Gardens and walk along York Street to the southwest corner of the Morrison Center, you will see four old trees growing in a row along the south property line of the center. These trees are all that remain of a hedge planted when the house which first stood on this site was built.

Maclura pomifera is the only representative of the genus *Maclura* in North America. Its original range was in the rich bottomlands of Arkansas, Oklahoma, Louisiana, and Texas. It was most abundant and reached its largest size in the valley of the Red River in Osage Indian territory. *Maclura pomifera* is now naturalized throughout the eastern half of the United States except along the northern border.

Osage orange trees are small to medium-sized trees with a short trunk which divides into a few large limbs forming a crown sometimes rounded and symmetrical but more often irregular in contour. They are characterized by a thick, slightly acrid milky juice.

The bark is dark orange-brown and deeply furrowed, with a scaly or shreddy surface. The twigs bear stout, straight spines $\frac{3}{8}$ -1 inch long making it a good hedge tree.

Leaves are oval or narrowly oval, 2-5 inches long, long-pointed, with smooth (entire) edges. They are shiny dark green above and paler beneath.

Osage oranges are dioecious—that is, male and female flowers are borne on separate trees. Tiny green flowers are produced in clusters in late spring. By late summer or early fall, the clusters of pistillate flowers will have developed into green balls which at maturity will become yellow-green fruits 4-5 inches in diameter.

Technically the fruit is known as a multiple fruit, consisting of the ovaries of several separate but closely clustered flowers. As the fruitlets grow, they are crowded together and coalesce to form a multiple fruit. Compound fruits of this type are characteristic of the mulberry family, Moraceae, to which Osage orange, mulberry, and fig belong. In *Maclura*, small individual drupes coalesce to form large orange-like fruits which are unpalatable because of their bitter milky juice and coarse fibrous texture. The orange-like appearance of the fruit and the fact that it was so common in Osage Indian territory gave the tree the name Osage orange.

Early settlers recognized the merits of this tree for formidable thorny hedges and planted it so widely that it was sometimes called hedge plant. It is from these hedges that Osage orange has become firmly established in many parts of the midwest.

Kansas, in 1865, was the first state to provide a tree-bounty law to encourage

Helen Marsh Zeiner, Ph.D., writes Exotics of Colorado as a regular feature in *The Green Thumb*.

planting of single-row shelter belts. The United States Department of Agriculture reports that 39,400 miles of single-row Osage orange hedges and shelter belts were planted between 1865 and 1939 by the farmers of Kansas as a result of this bounty.

Osage orange hedge fences are no longer as common as they were just a few years ago. Land has become so valuable that many have been dug up and replaced by less space-consuming wire fences.

Osage oranges are sometimes planted for ornament and shade, largely because of their shiny leaves but also because they are hardy and drought resistant.

The wood of Osage orange is very hard and strong and somewhat flexible. The Osage Indians and other Indians west of the Mississippi River found the wood ideal for bows and war clubs. Archers today still value Osage orange wood for archery bows. This use of the wood led to the common names bow wood, and bois-d'arc, and bodark.

Very durable in soil, the wood made long-lasting fence posts and railway ties. In early days the hubs and rims of wheels

of farm wagons were often made of Osage orange. Pulley blocks are sometimes made of this wood. Osage orange is also a desirable fuel wood.

Indians dyed their blankets with yellow dyes from the bark of the roots, the dark orange inner bark of the trunk, and the lemon-colored sapwood. Tan and khaki dyes were also derived from the bark. The bark of the trunk yields tannin, used in treating leather.

The tree was introduced into Europe as a possible food for silkworms.

The genus name, *Maclura*, comes from the name of American geologist and agriculturist, William Maclure. *Pomifera* refers to the fruits. ♀

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Osage Orange — fruit and leaf

A GEM FROM THE DRAKENSBERG

A Hardy Ice Plant New To Cultivation

by Panayoti Kelaidis

Visitors to California from colder states are struck with the extensive use of ground covers along the many free-ways that crisscross that state. Ground covers are used not only for highway beautification but also for controlling soil erosion. Among the many ground covers, several species of ice plant, *Mesembryanthemum*, in the live-forever family (Aizoaceae) are frequently encountered. These not only root readily from cuttings and grow rapidly but will produce a mass of showy bloom over a long period of the growing season.

The great bulk of the plants in this family originates in South Africa, where they are especially frequent in the desert regions such as the Karoo north of Cape Province. Although frosts are known to occur throughout South Africa, most of this nation is distinctly subtropical in climate.

The possibility that there might be hardy representatives of this family in South Africa would have struck sensible horticulturists as absurd only a few years ago. I can hardly be blamed for being a little skeptical when I first noticed a diminutive species of ice plant at several rare plant nurseries in the Northwest when buying plants for Denver Botanic Gardens' new Rock Alpine Garden. This tiny species was usually labelled either *Mesembryanthemum* sp. 'Basutoland' (Basutoland is the old name for the state

of Lesotho), *Mesembryanthemum criniflorum* or *M. othonna*. One of the nurserymen there insisted that I take a few plants along to try in Colorado, where he was sure they might be hardy. These were planted in the Rock Alpine Garden in the autumn of 1980 out of a sense of duty rather than any hope they might really survive: the Rock Alpine Garden gets a trifle colder than the highways of California.

From this point on, the progress of this little ice plant is well known to local plant enthusiasts. The original planting of three tiny plants was to spread relentlessly and rapidly to cover a tremendous area. Few plants propagate more easily than this miniature carpet. By the spring of 1983 large quantities of it were grown for the rock garden and ground cover booth at Denver Botanic Gardens Annual Plant Sale. It has found its way into most wholesale nurseries in the area where those three original starts have now been cloned into tens of thousands of plants which are flourishing in thousands of Colorado gardens. It is even growing successfully in Vail, Evergreen and Dillon — localities with a climate rather different from Los Angeles.

The plant itself has great appeal; it roots with great ease, rapidly forming broad mats of emerald green foliage that turn a glowing ruby color in winter months. As soon as hot weather returns in spring, the mounds resume a bright green color, and by May the foliage disappears beneath a mass of 1½-inch wide

Panayoti Kelaidis is curator of the Rock Alpine Garden at Denver Botanic Gardens.

chalices of yellow bloom. Not only does this remarkable plant possess sterling qualities in foliage and blossom, but it has shown a tremendous tolerance to varied soils from rich loams to heavy clays and sandy soils as well. It may be the only ground cover that will actually grow and flourish on a 3-inch thick veneer of soil spread over concrete. In the Pacific Northwest, throughout the Rocky Mountain region, in the Midwest and throughout the eastern seaboard this tiny succulent has proven to have unprecedented vigor and hardiness. This is obviously a wonderful addition to local gardens.

More research quickly uncovered a

new problem. What was the real name of the little ice plant? Both specific epithets were utterly nonsensical. The genus also was in question. *Mesembryanthemum* consists of only a few, giant, coastal Aizoaceae that have little in common with this tiny plant.

Further probing determined that the plant belonged to the genus *Delosperma*. Since this genus contains over 140 species of ice plants, many of which are similar in overall morphology, the question of names was by no means settled.

I was joined in my search for the proper name for this plant by John Wurdack, a taxonomist at the Smithsonian Institu-



Delosperma nubigenum, Hardy Ice Plant at Denver Botanic Gardens

tion, who had also been puzzled by the sudden apparition of this same plant in gardens throughout the eastern seaboard region under a variety of names. The same ice plant was being grown as *Conophytum pillansii* Lavis, *Delosperma lineare* L. Bolus as well as a wealth of new spellings and misspellings of various specific epithets of *Mesembryanthemum*. Surely, not many plants of such tiny dimensions have ever had quite so many names heaped upon them.

The final irony came when three different botanists specializing in Aizoaceae were to give John Wurdack three different species names for this plant. More study revealed that its proper Latin name is *Delosperma nubigenum* (Schlechter) L. Bolus — the cloud-loving *Delosperma*. The name is appropriate since this hardy ice plant only occurs within a tiny range at the highest altitudes of the Drakensberg Mountains on the border of Orange Free State, Lesotho and Natal in South Africa. Although I have been teased for including an ice plant in the Rock Alpine Garden, this species does occur naturally above treeline where it is subjected to severe alpine conditions.

The success of the yellow, hardy ice plant has encouraged testing other South African alpine plants: the Drakensberg Mountains contain a wealth of plant material, much of it belonging to genera — and even families — non-existent in the Northern Hemisphere. A surprising number of these plants are very drought tolerant, a quality that is sure to make them especially valuable to us in Colorado.

One of the richest groups of South African wildflowers is the genus *Helichrysum*, a group of composites in the Inula tribe that are related to our native pussytoes. Most of these have the characteristic curry scent that is found in the Mediterranean *Helichrysum* species employed in herb gardens. Several hundred helichrysums occur in South Africa, a large number at high altitudes in the Drakensberg. So far, six species have survived at least one Colorado winter with no significant damage.

Other groups of South African wildflowers also are being grown. Red hot pokeres are probably the best known group of South African perennials that are sold at many local nurseries. *Crocosmia* and kaffir lily have been grown for many years by Paul and Mary Maslin in Boulder. A minuscule crassula, *Crassula milfordiae* Byles has been grown and even propagated locally by several nurseries under the impression that it was a sedum.

Nor have other Aizoaceae been neglected: Alf Jensen, a local nurseryman, had grown *Stomatium fulleri* L. Bolus out of doors for many years. Plants were obtained from his nursery when the stock was dispersed upon his retirement and planted in many sites around the Rock Alpine Garden. It has proven to be hardy, if not as vigorous as *Delosperma nubigenum*. There were reports that another species, *Delosperma cooperi* (Hook. f.) L. Bolus, is reputed to possess great hardiness. Seed obtained in 1983 produced a large colony of rapidly spreading plants by the following summer. This species comes from somewhat lower elevations in the Orange Free State and the foothills of the Drakensberg. Unlike the yellow ice plant, it doesn't appear to root along the ground. The gray succulent leaves are characterized by crystalline exudations that have given the family its common name, ice plants. This species produces a constant succession of bright rose-purple blossoms more than an inch in diameter for the entire summer season, extending all the way to frost.

The recent experience with hardy ice plants has not only added a vigorous, carefree ground cover to our landscape palette; it has opened a door to a whole new continent of possibilities. Hitherto it seemed that the only durable plant material for our continental, semi-arid climate would come from our own western states or from similar climates in Asia. Now it appears that there is a rich source of hardy, drought-tolerant plant material in the Southern Hemisphere that few had ever suspected. What other gems lie hidden in the Drakensberg? ❁

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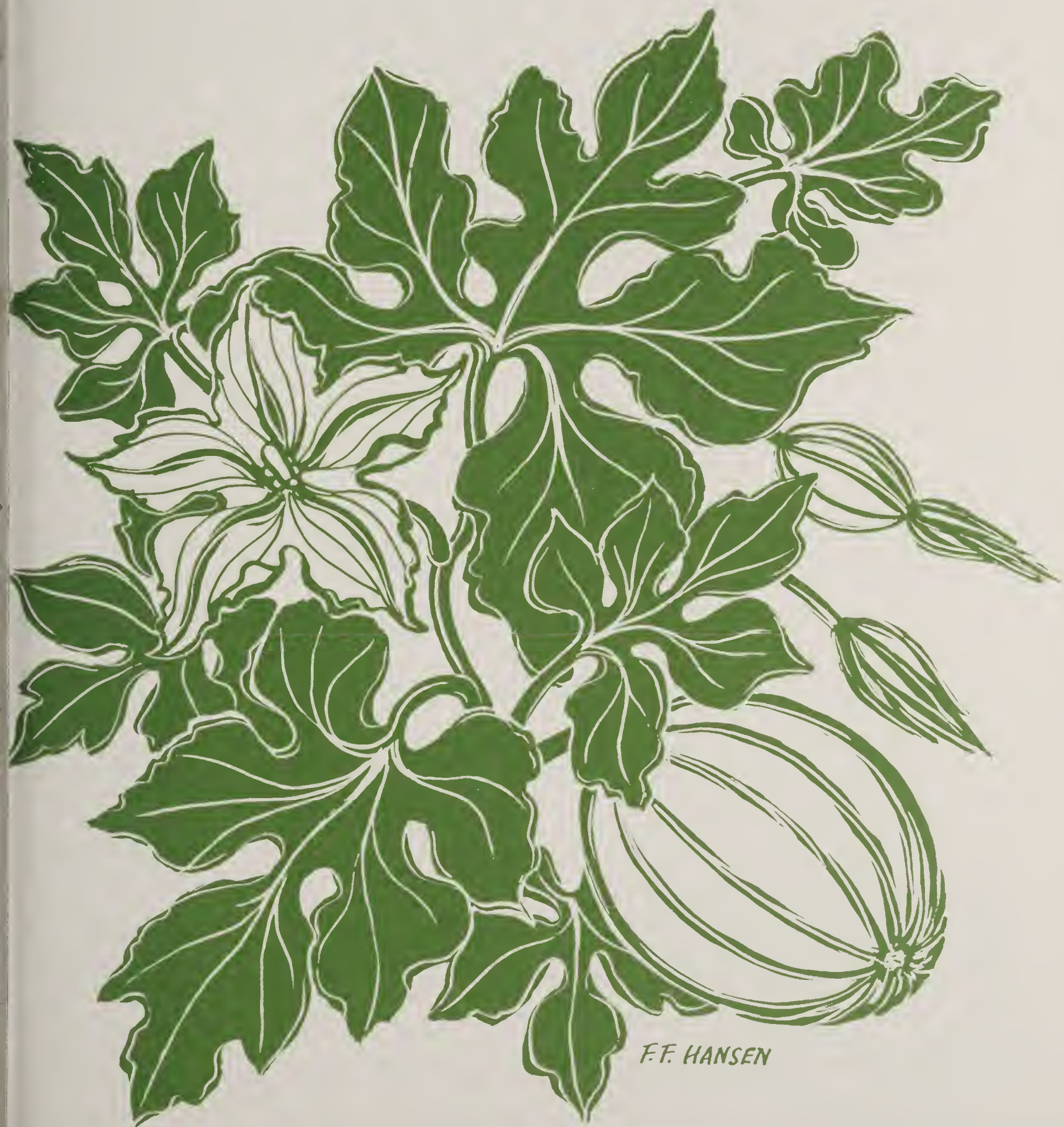
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Denver Botanic Gardens, Inc., maintains a collection of living plants, both native and exotic, for the purpose of acquiring, advancing and spreading botanical and horticultural knowledge.

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American Indian Fare for Thanksgiving

by Patricia A. Pachuta

The American Indians have had a tremendous yet unsung influence on our American cuisine. From clambakes to barbecues, these first Americans developed a wholesome and varied diet and many of our most traditional and classic American dishes were gifts from these earliest Americans. Boston baked beans, cranberry conserves, roast turkey and goose, steamed lobsters and oysters, clam chowder, Brunswick stew, mincemeat pie, and cornbread are all examples. The American Indians taught the unprepared colonists skills that sustained them through the first harsh winters; yet we tend to think of these dishes as New England food and forget their true origins.

Long before Columbus "discovered" America, the American Indians had developed a native cuisine with many regional differences. Indians of the Northeast were skilled agriculturists whose expertise with corn, beans, and squash is legendary; the nomadic Plains Indians pursued the buffalo and depended upon it for clothing and shelter as well as for food, while those of the Pacific Northwest were expert fishermen. Wherever they lived, the American Indians adapted to various climates and their tribal foods reflect this.

Patricia A. Pachuta, education director at Denver Botanic Gardens, teaches classes on the varied uses of herbs and has published several articles on the subject.

The 102 Pilgrims who came to the Cape Cod area on the *Mayflower* in November of 1620 were aided greatly by Massasoit, the leader, and the other members of the Wampanoag Confederacy that ruled southeastern New England. They learned how to plant corn; although their first harvest was meager, the Pilgrims decreed a holiday of thanksgiving to rejoice together. As George F. Willison reports in *The American Heritage Cookbook*:

"Four men were sent to hunt waterfowl and brought back enough to supply the town for a week. Massasoit had been invited to attend, and came with ninety brightly painted braves, some of whom went out and brought in five deer and other good things from field and forest. It was a gala occasion, enlivened with games of chance and skill, and it went on for three days with the Pilgrims and their guests gorging themselves on venison, duck, goose, and probably turkey, clams and other shellfish, smoked eels, corn breads, leeks and watercress and other greens, with wild plums and other berries as dessert—all washed down with wine made of the wild grape."

The holiday was well received and the Pilgrims continued these celebrations. Gradually, the custom spread as the New



E. Barrie Kavasch serves students of "American Indian Cookery: the Original American Cuisine."

England residents moved on to settle other parts of this vast country. In 1863, President Lincoln proclaimed the first national Thanksgiving Day and it continues to be celebrated on the last Thursday in November. Considering the strong culinary influence the American Indians had on the early colonists, it is hardly surprising that our present Thanksgiving Day menu reflects the early New England tastes and customs that the Pilgrims adopted from their American Indian friends.

Through the generous support of the Bonfils-Stanton Foundation, Denver Botanic Gardens was fortunate to host the Smithsonian Institution's traveling exhibit, "Native Harvests: Plants in American Indian Life," for six weeks in early 1985. The show consisted of approximately 100 plant-related artifacts made by American Indians from various regions of the United States. John C. Mitchell II Hall was filled with objects such as gourd and cornhusk masks, pine needle baskets and seed jewelry. Various special activities were held and the curator of the show, E. Barrie Kavasch, visited Denver for a week to lecture and

teach.

E. Barrie Kavasch is a noted expert on plant uses by the North American Indians. She is the author of six books including a cookbook of North American Indian recipes, *Native Harvests*. Her two-session course, "American Indian Cookery: the Original American Cuisine," proved so popular that three sections of 18 students each were quickly filled. The fare included Indian cuisines of the Northwest coast, the pueblo Southwest, and the tribal Northeast. Traditional cooking techniques were adapted to modern facilities and the students enjoyed such regional delicacies as Iroquois wild mushroom soup with corn dumplings, Kwakiutl smoked salmon, Navajo fry bread, Yakima spiced sunchokes, and Muckleshoot wild raspberry pudding. The recipes chosen for the course highlighted readily available ingredients in authentic American Indian recipes.

The infectious enthusiasm of our teacher coupled with the tantalizing aromas and flavors sparked my interest in this new cuisine. Although it was only February, I had already decided that

my very next Thanksgiving Day menu would reflect these new ingredients and techniques.

Local produce counters periodically offer two ingredients that Indians of the Southwest and Mexican cooks share: jicama and nopales. Jicama (pronounced hee-ka-ma), *Pachyrhizus erosus* (L.) Urban, is a round brown tuber that resembles a turnip but is a member of the legume family. Known also as the Mexican potato, it has a crunchy mild flavor that is not unlike water chestnuts. Its juicy crispness makes it ideal for soups and salads. Or, it may be lightly steamed and seasoned. Choose firm, small tubers, since the large ones may be woody, and remove the thin peel before eating.

Nopales or cactus pads are the jointed stems of several species of *Opuntia*. (Cacti, except for a few primitive types, lack leaves except when young.) Shaped like beaver tails, they are frequently available fresh. The best flavored, most tender pads are small and thin, so choose accordingly. If possible, select the spineless variety for ease of preparation. Otherwise, scrape off the spines but take care not to remove the entire green skin.

Cut nopales into small pieces and cook in salted water until tender. Fresh nopales, like okra, exude a gelatinous juice easily removed by rinsing in cold water after cooking. Canned or bottled nopales are a time-saving substitute; the pickled variety is labeled "en escabeche."

Indians from all over the country ate many kinds of roots and tubers including Jerusalem artichokes or sunchokes, *Helianthus tuberosus* L. While native to North America and extremely popular in Europe, they are less popular in this country. The tubers come from a perennial member of the sunflower family that, once planted, is difficult to eradicate. The brown, gingerroot-shaped tubers are readily found packaged in plastic bags in supermarket produce sections. A pound provides about four servings.

With a flavor similar to potatoes, yet nuttier, Jerusalem artichokes are delicious raw or boiled, roasted, fried, or marinated. Select firm, unshriveled tubers

and scrub well with a vegetable brush. Although the peel is thin and tender, you may wish to remove it. If so, scrape and immerse the tubers in water acidulated with a bit of vinegar or lemon juice to prevent darkening.

One of the many ways that Southern American Indian tribes prepared these tubers was by ash cooking, a technique of roasting food in the hot ashes beside an open fire. Food cooked this way was generally first wrapped in leaves which left it succulent and moist.

Wild rice, *Zizania aquatica* L., is not a rice at all but rather a nutritious grain from marshy areas in the shallow lakes of the northern United States. It was extremely important to the Chippewas who harvested it in autumn by paddling canoes among the ripened seed heads. The seeds were flailed into the canoe bottoms and later collected for processing. It is still harvested in this time-honored way on Chippewa lands in northern Minnesota, the principal source of the United States crop.

After sun-drying on mats or parching in a kettle on an open fire, wild rice is threshed and winnowed to remove its husks and chaff. This extensive processing is unfortunately reflected in the high cost of this relatively scarce grain. Although the hulls are removed, wild rice is as nutritious as unpolished rice or whole wheat—a healthy consolation. It is chewier and nuttier than white rice and cooking times can vary considerably, although it usually takes 40 to 60 minutes of simmering.

The Southwestern Indians prize the edible seeds of *Pinus edulis* Engelm. that are contained within their cones. Called piñons, pine nuts, or even Indian nuts, they are gathered in the fall and roasted. They are treasured by the Hopi who usually save them for visiting friends and family. The sweet delicate flavor of piñons enhances appetizers, soups, and salads. The entire crop in the United States is harvested by Indians and comes mainly from wild native trees in New Mexico and California.

Beans have always been extremely im-

portant to native Americans, particularly in the Southwest; the Papago tribe name means "bean people." The dish that came to be known as Boston baked beans was originally prepared by pit baking. All kinds of food including seafood and vegetables were buried in holes heated by coals from slow-burning fires.

American Indian cooks were expert at preparing the abundant fish and seafood that inhabited their waters. Salmon

reigned supreme in the Pacific Northwest while lobsters, scallops, mussels and other seafood were all prized in the east.

The following recipes, all from E. Barrie Kavasch, were chosen to encourage you to enjoy dishes with an American Indian culinary influence. Perhaps this is the year you'll experiment with a truly native American menu for Thanksgiving.



Students prepare to sample an American Indian luncheon.

Baked Stuffed Squash

- 4 acorn squash, washed
- 1 tablespoon honey
- 1 cup applesauce
- ½ cup raisins
- 1 tablespoon sunflower seed butter
- ½ teaspoon allspice, ground
- ½ teaspoon salt
- ½ cup apple cider, for basting

Place the whole squashes in a baking dish in a preheated 350°F oven for 40 minutes. Remove from oven and allow to cool slightly.

Slice a lid off the top of each squash and spoon out pulp. Spread the hot seeds over a lightly oiled, foil-covered baking sheet and toast in the oven for 10 minutes until golden. Reserve seeds for garnish or a condiment.

Scoop out most of the flesh from each squash leaving about ½-inch shell so it will hold its shape. In a bowl, mash the flesh with honey, applesauce, raisins, sunflower seed butter, allspice and salt, and return the stuffing mixture to the shells. Top with the lid and return to the oven for another 15 minutes, basting frequently with cider. Serve with roasted seeds as an accompaniment.

Yield: 4 to 6 servings

Note: Sunflower seed butter is available in health food stores and some markets. Most of the other seed and nut butters are available only in health food stores or may be refined in the kitchen with mortar and pestle, blender, or food processor.



Jicama-Sunchoke Salad.

Jicama—Sunchoke Salad

- 1 large jicama, peeled & sliced
- 1 pound red kidney beans, cooked
- 2 cups sunchokes, cut in chunks
- 1 large bunch watercress, cut
- 2 sprigs parsley, chopped
- 2 sprigs coriander, chopped
- 2 cloves garlic,
peeled & diced
- ½ cup green peppers, chopped
- 1 cup sunflower seed oil
- ½ cup apple cider vinegar
- dash of pepper, to taste
- 1 small onion, diced

Combine all ingredients in a large bowl. Toss well.

Marinate at room temperature for 1 hour.
Toss again and serve.

Spiced Jerusalem Artichokes

- 1 pound Jerusalem artichokes,
scrubbed and sliced
- ½ cup sunflower seed oil
- ½ cup cider vinegar or
lemon juice
- ½ teaspoon dill seed
- 2 cloves wild garlic, chopped
- 2 tablespoons chives, chopped
- 2 tablespoons fresh dill, chopped

Boil artichoke slices in water to cover for about 5 minutes. Drain off water and leave chokes in pot. Pour oil and vinegar over and add dill seed and garlic. Mix thoroughly and simmer for 10 minutes, stirring frequently. Sprinkle with chives and dill.

Serve hot or cold as a side dish or as a relish.
Yield: 4 to 5 servings

* —————

Nopales—Piñon Salad

- 2 quarts prickly pear pads
- 2 quarts water (to cover)
- ⅓ cup apple cider vinegar
- ⅓ cup sunflower seed oil
- 1 small clove garlic
- 2 slices of onion
- ⅓ cup piñon nuts, shelled
- 2 sprigs fresh coriander, chopped
- 3 Tbsp. honey
- dash of pepper, or cayenne

Select choice young pads. With tongs, hold each pad over flame and singe off the needles.

Place pads in a kettle, and cover with water. Add the onion slices and a cut clove of garlic, and low-boil for 25 minutes. (The Hopis add an ear of sweet corn for the flavor.) Drain.

Clean and peel the pads, and dice or cut into slender strips. Place in a broad bowl. Sprinkle the piñons over all.

Heat remaining ingredients in a small sauce pan until honey is melted and well blended. Pour over the nopales and piñons, and allow to sit (developing flavors) at room temperature for 30 minutes.

Serve on a bed of fresh watercress and lettuce.

Wyoming's Early-Day Botanist: Aven Nelson

by William G. Gambill Jr.

During my undergraduate days at the University of Colorado, in the 1930s, I was introduced to the use of the *New Manual of Botany of the Central Rocky Mountains (Vascular Plants)* by John M. Coulter and Aven Nelson, published in 1909 by the American Book Company. At that time this was the most satisfactory book available, and nearly the only one, for the identification of plants of the native flora of the Boulder area. To a beginning student in botany, use of the keys in this book to determine unknown plants presented formidable difficulties; but with perseverance and an instructor's help one could triumph. I knew little about the authors except that John Coulter was professor of botany at the University of Chicago and Aven Nelson held a similar position at the University of Wyoming. Both of these men were distinguished botanists by that time, and one of them had been living for years not all that far from Boulder.

Fifty years have elapsed since my struggles with the Coulter-Nelson *Manual* and 75 since its publication. At this late date I have become reacquainted with the *Manual* in a stimulating encounter with the life story of its junior author, that same Aven Nelson who was

making botanical history across the border in Wyoming long before I attempted to use his book, and whose career ended 33 years ago.

The source of my recent enlightenment is an exciting new book entitled *Aven Nelson of Wyoming*, written by Roger M. Williams, Distinguished Professor of History at the University of Wyoming, and published in late 1984. It will be pertinent to quote a statement from the dust-jacket of this new book: "Although primarily a French historian, Williams was drawn to Aven Nelson through his own avocational interest in Rocky Mountain botany; and because of his desire to make his fellow citizens aware of the treasure that Nelson was for Wyoming."

When Williams requested permission in 1979 to write Nelson's biography, he tells us (p. xi) Ruth Ashton Nelson (the second Mrs. Aven Nelson) graciously granted it and made available her husband's voluminous botanical correspondence along with many personal books, papers and notes, all of which have become the property of the University of Wyoming. Drawing on these materials and numerous other sources, Williams has produced a penetrating biography of the man who was recognized as the leading authority on Rocky Mountain plants for over a third of a century. The book also presents a fascinating account of Nelson's contemporaries in systematic botany and shows how the shifting winds of botanical philosophy influenced his work and the

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progress of this particular aspect of botany.

Again, in his preface (p. ix), Williams summarizes the significance of Nelson's life for us today: "Aven Nelson was born in 1858 and died in 1952. Every life could be an engrossing story if every man should have a biographer, but the life of Aven Nelson was extraordinary in many ways. Its interest for the modern reader depends largely upon two considerations: the light that his career throws on the spirit of his age in the American West, and those capacities that combine to create the truly seminal teacher."

Nelson became a member of the faculty of the University of Wyoming in 1887, the year the university opened, and three years before Wyoming achieved statehood. The first building on the campus was not yet completed. The campus was natural prairie dotted with sagebrush and inhabited by jack rabbits, sage grouse, and, no doubt, prairie dogs, and was used by the local stock as a pasture. For 55 years, until his retirement in 1942, this man was very closely associated with the growth and development of the university, and also of Wyoming as a state.

The book, *Aven Nelson of Wyoming*, makes fascinating reading. One is tempted to say that it reads like a biographical novel, except that there is no fiction in it, for this is a true story with an extraordinary base of documentation throughout. Williams has chosen the ingredients of his biography so perceptively, and woven them together so skillfully that the story almost seems to tell itself. His sound grasp of the principles, the vocabulary and the methods of systematic botany along with his personal experience in botany furnish the solid credibility evident throughout the book. One need not be a botanist to enjoy this book, but those with a background in systematic botany will find it of special interest.

Details of the emigration of Nelson's parents from the agricultural area of Espevig, near Stavanger in Norway to the Sugar Creek Colony of around 30 families in southeastern Iowa are scarce. His

father emigrated in 1843 at the age of 23 to test life in the New World. His future wife arrived in 1848; they were married in Chicago on the day of her arrival and started for Iowa the following day in a prairie schooner drawn by oxen. They settled on acreage filed for earlier by Nelson's father and developed a small farm there in the wooded, hilly country of southeast Iowa. This rural environment was very significant in the early life of Aven, who was the youngest of four children, and who later recalled with obvious pleasure their searches for the first wild flowers of spring on the hilly brushlands of his father's farm. Williams (p. 1) ventures to state that "The botanist had been in the boy from the beginning." Nelson's parents held strong Quaker beliefs by which they lived and which they passed on to their children. This was evidenced in Nelson's strong personal religious beliefs although he did not formally become a Quaker, but rather was a staunch Methodist all his adult life.

Aven Nelson's earliest education was what he received at a little country school a few months each year. In later years he was still able to quote verses he learned from the McGuffey *Readers* at that time. At age 16 (in 1875) he enrolled in a combination "college" and "normal institute" in a neighboring county, the equivalent of a secondary school, run by the Society of Friends. After one year there he qualified for a Teacher's Second Class Certificate, was hired to teach a 4-month term at \$25 per month, and thus at age 17 he entered the classroom for the first time. He was older than some of his pupils, and younger than others. The next fall he had earned a First Class Certificate to teach another term. The money he earned he saved for college, and he kept up his reading in preparation. In the fall of 1878 he entered Missouri State Normal School at Kirksville without a high school diploma. He completed two years of the course in one year and earned another teaching certificate, and thereafter alternated a year of teaching with a year at the college, receiving a Bachelor of Arts and Didactics degree in 1883. He had prepared



Aven Nelson: distinguished scholar and gifted teacher.

for a teaching career specializing in English and expecting to teach numerous other subjects. He was valedictorian of his class and was voted the outstanding student, besides winning the gold medal in the annual oratorical contest. By that time he had also met his future wife.

Before graduation he had accepted a position at Drury College in Springfield, Missouri at a salary of \$700 per year. At Drury he was to teach English and assist in biology. He remained there two years. Then he accepted a better paying position as a superintendent of schools near St. Louis where he was to earn enough to enable him to marry Celia Alice Calhoun

in September 1885. Their first daughter was born one year later. By the end of the second year of the superintendency Nelson had accepted an offer from the University of Wyoming. At this point he still had no formal training in botany.

From Williams' account we learn that Nelson was first hired to teach English at the University of Wyoming, but that the board of trustees had inadvertently hired two professors of English, Nelson being the first. However the second had a new master's degree in English from Dartmouth College and thus was given precedence. Nelson was hired as Professor of Biology, with his other assignments

as follows: librarian for 300 nearly useless volumes; to give instruction in calisthenics, physical geography, economic botany and zoology, animal physiology and hygiene. This variety of courses was created to conform, by necessity, to the First Morrill Act of 1862, and even so there was no instruction in some of Nelson's subjects at first; but calisthenics was deemed critical. In 1891 he was relieved of the library duties but named Professor of Botany and Horticulture when these programs went in at the university and the Experiment Station was established. He was given no increase in pay at this time.

By 1891 Nelson was experiencing great concern over his ever-increasing need for serious graduate work to enable him to meet his scientific responsibilities. As a consequence he worked out an arrangement with the new president at the university who would buy his house and furniture thus providing the funds for a year's leave of absence to do graduate work at Harvard in 1891-92. He received the M.A. degree from Harvard in June 1892, his course work having emphasized the morphology and physiology of both plants and animals. While he was at Harvard, the Nelsons' second daughter was born. Upon the return to Laramie, they bought back their house and furniture.

Nelson's first serious concern with plant identification started in early 1893. With no knowledge of systematic botany and only a half dozen books on the subject, he began working on Wyoming plant specimens collected during his absence by Burt C. Buffum, the instructor in Agriculture and Horticulture at Laramie. He then sent a group of plants for naming to J. N. Rose in the Department of Agriculture in Washington, who also gave help in the methods and procedures involved in the naming and publishing of new plants. Rose visited Wyoming that year (1893) to collect plants for himself, and his friendship with Nelson was valuable in encouraging the latter's professional understanding and aspirations. In the summer of 1893 Nelson actively

began collecting and preserving Wyoming plants from the Laramie area. This brought to the fore the need for proper herbarium cases to store the specimens; cases were made at the university to Nelson's specifications. Thus was started the herbarium at Laramie. By 1899 it was officially named the Rocky Mountain Herbarium, still its name today. And so, too, was launched the career in systematic botany which Aven Nelson would pursue for nearly fifty years. Williams (p. 24) quotes from an article written in later life by Nelson that his work on plant identification in 1893 "kindled the fires that burn perennially in the heart of the investigator, whether it be the natural or physical world or in the realm of the mind. The road that seems to lead into unexplored fields is singularly attractive, especially so if hazards bar the way." As Williams concludes: "He (Nelson) was one of those happy few who are fascinated for life."

The material excerpted thus far comes from the early pages of the Williams book. For the interested botanist, and others, rich rewards lie in following to the end this account of Nelson's career. The wealth of fascinating stories in this biography obviously cannot be dealt with here. Among them are these: Nelson's botanical explorations in Wyoming's Red Desert and in Yellowstone National Park, in a day when botanizing had to be done by train, horse and wagon, and on horseback; the account of Nelson's completion of the Ph.D. degree from the University of Denver in 1903; Nelson's professional encounters with the "splitters" E. L. Greene and P. A. Rydberg as well as with numerous other prominent botanists of the period; his meeting with John M. Coulter of Chicago and his subsequent collaboration with him on revising the *Manual*; Nelson's magnetism for students (many whose names became well-known botanically); the five years of Nelson's presidency of the University of Wyoming and the interesting behind-the-scenes glimpses of the politics involved; receiving the honorary Doctor of Science degree from the University of

Colorado in 1926 at the behest of Dr. Francis Ramaley; founding of the Colorado-Wyoming Academy of Science in 1927, arranging its affiliation with the American Association for the Advancement of Science and serving as its first president; serving as President-General of the Honor Society of Phi Kappa Phi, 1932-35; election to the presidency of the Botanical Society of America in 1934; his influence in establishing the American Society of Plant Taxonomists and serving as its first president in 1935; and the botanical exploration of McKinley National Park with Ruth Ashton Nelson and collecting of plants there.

A valuable feature of the book is found in Appendix A, where Williams has listed in historical sequence the genera and species published by Nelson in the course of his research on Rocky Mountain plants. Roughly 975 Latin designations are placed here to which Williams has added the current synonymy. He includes synonyms because he did not want the reader to get the impression "that Nelson's published work did not amount to much—that a majority of his new species did not stand. The general reader in particular needs to realize that Nelson's record in this respect was little different from Greene's and Rydberg's. Many of their species have been reduced to synonymy with the passage of time. Of the three, Nelson seems to have been the most aware that scientific knowledge advances on the basis of a willingness to risk error" (p. 325). When new names did not stand, he apparently took dissent more gracefully than the other two. Williams also goes on to point out that a substantial number of Nelson's species, having once been reduced to synonymy, have been revived as subspecies or varieties, and a number of his generic names are now being revived by some authors.

In Appendix B, Williams has listed Aven Nelson's botanical and horticultural publications in chronological order. Over 140 titles are to be found here. Included, of course, is the *New Manual of Rocky Mountain Botany (Vascular Plants)*. This book was enthusiastically

received by the great majority of American botanists as an impressive taxonomic work and one which filled a pressing need. It brought well-deserved recognition to Nelson and "served to advertise Laramie as the capital of Rocky Mountain botany. The upsurge in enrollment (at the University of Wyoming) was immediate, not a tidal wave to be sure, but a steady procession of gifted and dedicated students" (p. 167).

Aven Nelson was above all a dedicated teacher and exerted a powerful influence on the numerous students he attracted, quite a number of whom achieved outstanding careers in botanical pursuits. In the preface to his book (page x) Williams makes the following comments about how Nelson's students viewed their teacher: "Despite their great respect for Nelson's contributions to science, his students were wont to believe that the inspiration he gave them was his most notable achievement. Not only did he spawn botanists, but he remained in their minds as a father to be emulated. And scores of Wyoming students, without talent or inclination to become botanists, looked upon our plains and mountains with a sharpened eye for the remainder of their lives. Where others might see nothing in particular, they saw a galaxy of life."

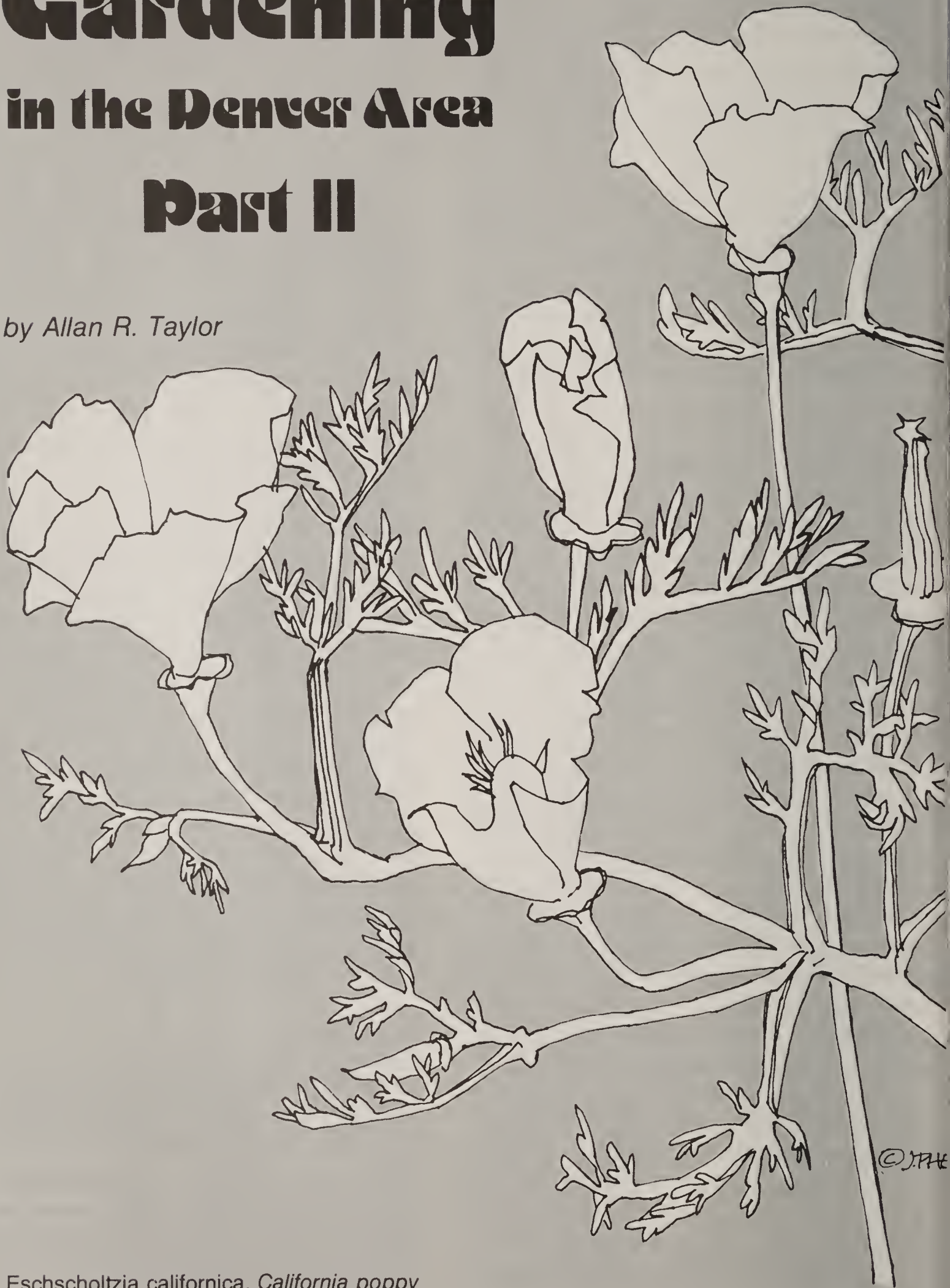
Aven Nelson of Wyoming is truly a unique contribution to the botanical literature of our country. Had this book not been written, a vital segment of the history of botany in the American West might have remained unrecorded. This story needed to be told before it was too late, and Williams is to be honored for his recognition of the need. His book adds immeasurably to the richness of our western cultural heritage. ❀

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Desert Gardening in the Denver Area Part II

by Allan R. Taylor



Forbs

Included here are herbaceous and subwoody plants, but the line between these two, and between these and other possible classifications, is blurred. Under certain conditions, for example, a plant that is ordinarily subwoody becomes woody. Or again, a plant may be fruticose enough to qualify as a genuine shrub. The major criterion for placement in this group, however, is that these plants are of interest primarily because of their showy

flowers; shrubs, on the other hand, are grown more for their form or foliage color than for their flowers.

Forbs are of two kinds: annual and perennial. Biennial plants are a problem in such a scheme, but it seems more appropriate, given their fixed life span, to assign them to the annuals. Also some plants that are perennial in favorable climates behave more like annuals in our region.

Annual Forbs

All drylands have a large number of plants called ephemerals that escape drought by spending the rainless periods in their seed stage. One good soaking is enough to cause the seed to germinate and proceed to the flowering and seed production stages, thus guaranteeing another generation after the inevitable return of drought kills the short-lived annual plant. This regime is complicated in a climate with pronounced seasons, as ours. For us, the "one good soaking" is less important than the return of weather warm enough to cause germination of the seeds.

Many attractive native annuals of the ephemeral type exist; only a few representative ones will be listed.

Unmatched among such plants is the California poppy, *Eschscholtzia californica* Cham., grown around the world, and not just in arid plantings. Its preferred habitat is, nevertheless, drylands. The commonest color of this beautiful poppy is a rich egg-yolk yellow, but it is also available in white, pale yellow, orange, and pink. An advantage—or disadvantage—

of this plant is that it seeds itself profusely. Where space is available it quickly takes over, and it can crowd out less competitive sorts. Judicious thinning is very much in order. Apparently even more attractive with filiform leaf segments and shorter-petaled flowers is its smaller cousin, *Eschscholtzia glyptosperma* Greene, but I have not grown it.

Other desert annual poppies are *Canbya candida* Parry and *Kallstroemia grandiflora* Torr. ex Gray, Arizona-poppy. *Canbya candida*, a tiny plant only an inch in height with white flowers, blooms profusely after desert rains. Though not a true poppy but a member of the caltrop family, Arizona-poppy is a trailing plant with large, rich orange flowers somewhat resembling those of the California poppy.

In the same color range are three composites, *Baeria chrysostoma* Fisch. & Mey., goldfields, *Malacothrix glabrata* Gray, desert dandelion, and *Viguera annua*, (Jones) Blake, annual goldeye. All three of these blanket the landscape with brilliant yellow when spring comes to the desert. *Baileya multiradiata* Harv. & Gray, desert marigold, has attractive yellow flowers, but the stems and leaves are a stunning silver color.

Often growing with these annuals are others of strongly contrasting color; it is this strong contrast combined with the

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brilliant light and clear air of the desert which makes the southwestern spring so exhilarating.

Frequently occurring with goldfields, *Baeria chrysostoma*, in its native habitat is *Nemophila menziesii* Hook. & Arn., baby blue eyes, whose upward-facing, sky-blue flower is reminiscent of a shallow campanula or a gentian. A beautiful dark blue annual with tubular flowers, possibly the best in its genus, is *Phacelia campanularia* Gray, desert bluebell. An Arizona species of nearly equal beauty is *P. fremontii* Torr. Its sky-blue to lavender corolla contrasts sharply with the bright yellow tube and throat. The phacelias are represented by many western species and merit a great deal of testing, since many must be apt garden subjects. Two other genera of worthy annuals are *Gilia*, closely related to the phloxes, and *Gode-tia*, farewell-to-spring, closely related to the evening primroses. Species of these

genera occur widely throughout the West in a great variety of habitats; there are also a large number of selected forms and hybrids.

Abronia, sand verbena, one of the most typical genera of the warm Southwest, should be represented in an arid planting. *Abronia villosa* S. Wats., native to Arizona and California, is a trailing, sticky-leaved four-o'clock that produces clusters of rose-purple flowers which perfume the afternoon air as do the familiar cultivated four-o'clocks. Other sand verbenas that should be tried are *A. nana* S. Wats., and *A. elliptica* A. Nels. Another showy trailing plant with reddish-purple, tubular flowers is *Nama demissum* Gray, purple mat. It is a relative of the phacelias and favors dry slopes in the Mojave Desert. Still another prostrate trailer is *Verbena bipinnatifida* Nutt. with lilac-purple flowers. Unlike the other annual plants listed here, this one



occurs throughout southern United States.

With dense bright lavender-purple spikes, *Orthocarpus purpurascens* Benth., owl clover, typically occurs in huge patches. Other closely related members of the same genus are also showy, as are many other members of the figwort family, e.g. the genus *Mohavea*.

Whether mixed or matched, these (and possibly other) brilliant-flowered annuals will make the arid garden the rival in the spring of any alpine rock garden, while at the same time capturing the essence of the desert spring that those of us in cold climates yearn for each year, and travel great distances to see whenever we can.

Perennial Forbs

In this group are almost an infinitude of species, some very well-known to cultivation, some not. Groups mentioned should definitely be regarded as topics for further investigation and testing by the individual gardener.

Sunflower family

An exceedingly important part of our na-

tive dryland flora is the composites.

Many are herbaceous perennials notable for their conspicuous flowers, most daisy-like and in the yellow range. All come readily from seed.

Among the very best are *Zinnia grandiflora* Nutt., wild zinnia, *Hymenoxis acaulis* (Pursh) Parker, bitterweed, and *Melampodium cinereum* DC., blackfoot



Zinnia grandiflora, Wild Zinnia

daisy. All are everblooming: they flower continuously from spring to frost. The blackfoot daisy has white flowers, the other two, golden yellow. Bitterweed occurs in many forms all over the West; the other two are native from southern Colorado south. Attractive, too, is *H. argentea* (Gray) Parker, perky sue, native in New Mexico and eastern Arizona. This low, silver plant produces dozens of large yellow daisy-like flowers on short stems.

Three other outstanding yellow-flowered composites are *Psilostrophe bakeri* Greene, paperflower, native in the Colorado River drainage of western Colorado, and *P. tagetina* (Nutt.) Greene, wooly paperflower, native in the Great Basin and the Southwest. *Psilostrophe sparsiflora* (Gray) A. Nels. is another species of the paperflower group. All are everblooming. The paperflowers are so-called because the petals of the ray flowers remain on the spent flower head, becoming dry and papery. The third yellow-flowered composite, *Encelia farinosa* Gray ex Torr., brittlebush, is native in the Mojave and Sonora Deserts of Arizona and California. Brittlebush has powdery-white stems and leaves as its specific name implies—a stunning contrast to the brilliant yellow of the ray flowers. Experimentation with this plant has just begun at Denver Botanic Gardens, and it is entirely possible that it will prove to be too tender, but may nevertheless be grown as an annual.

Also possible arid garden subjects are many of the yellow-flowered groundsels, *Senecio* species.

Other composite genera with many dryland species native in our region are *Townsendia*, Easter daisies, and *Erigeron*, the fleabanes. *Townsendia exscapa* (Richards.) Porter and *T. hookeri* Beaman of our area grow as low mounds producing dozens of white to pinkish- or purplish-white flowers. As their common name implies, these plants are among the earliest to flower in the spring. The fleabanes are usually found at high altitudes (montane-alpine zones), but some occur on the plains and in the foothills. They are also typically low mounds, their

flowers also whitish, although some are lavender or violet. *Erigeron pumilus* Nutt., whose ray flowers vary from white to blue-violet, is native to the plains and foothills.

A final composite group that should not be overlooked is the genus *Antennaria*, pussytoes. Several species occur in western North America, and most are hardy in our area, since each species typically has a broad altitudinal range. The outstanding feature of these wooly-gray plants is their mat-forming penchant: when given the opportunity, they colonize large areas making an excellent ground cover. The silver or rose-colored flower head looks superficially like the paw of a kitten viewed from below, hence the popular name. A common local species is *A. rosea* Greene, found from foothills to timberline.

Several other families that contribute herbaceous species to our native dryland flora suitable for a desert garden are the legumes, the figworts, the lilies, the evening primroses, the buckwheats, the phloxes, the mallows, the loasas, the vervains, the borages, the mustards, the morning glories, the four-o'clocks, the purslanes, the stonecrops and the ferns.

Legume family

The principal genera of the giant legume family of interest to us here are *Astragalus*, *Oxytropis*, and *Lupinus*. All occur from low to high elevations and must be propagated from seed that normally must be scarified. Attempts to collect these plants always fail, because injury to the taproot invariably causes the plant's death.

Literally hundreds of species of *Astragalus* populate western North America. Some are silvery, ground-hugging plants spreading out in all directions from a deep tap root. *A. sericoleucus* Gray, a native of dry banks in the western Great Plains, is a dainty little plant smothered with tiny, intensely fragrant, wine-colored pea flowers in early June. *A. coccineus* Brandeg. is a California na-

tive with scarlet flowers. We have had little success with this stunning *astragalus* here, and it may prove too tender for our area. Another lovely *astragalus* is *A. spatulatus* Sheldon centered in the Great Basin but reaching northern Colorado through Wyoming.

Closely related to *Astragalus* is the genus *Oxytropis*, the locoweeds, so-called because some species poison stock that eat them, causing the animals to behave erratically, if it does not kill them. Members of *Oxytropis* tend to be clump-formers, rather than mat-formers, with their lavender-pink flowers held aloft on long stems. The feathery foliage, as in *Astragalus*, may appear grayish because of its dense covering of hairs. A typical native *Oxytropis* which does well in cultivation is *O. sericea* Nutt., a white-flowered form found in the Denver area. A very showy purple-flowered form is *O. viscida* Nutt.

The lupines are a much beloved group whose stately flowers have adorned gardens since ancient times. The state of Texas has chosen the native annual, *Lupinus texensis* Hook. as its state flower.

Foliage of the lupines is frequently silvery pubescent, the leaves digitate, and five-petaled pea-like flowers develop around a tall spike. A number of species are apt subjects for cultivation in an arid garden. Best at Denver Botanic Gardens has been *L. argenteus* Pursh, native to our area. Another exceedingly handsome lupine is *Lupinus sericeus* Pursh, silky lupine, native in dry areas in the northern Rocky Mountains. Its flowers vary from blue to purple, some with a pinkish cast. It would certainly be hardy in the Denver area. *L. breweri* Gray, is a stunning mat-forming lupine from high altitudes in southern California. If it proves hardy here, it will be a very choice addition to our arid inventory. Much testing remains to be done with the native western lupines, and amateur gardeners should experiment with them. Desert representatives of other genera of the legumes (*Sophora*, *Lotus*, *Lathyrus*, and *Thermopsis*) also should be tried here for hardiness.

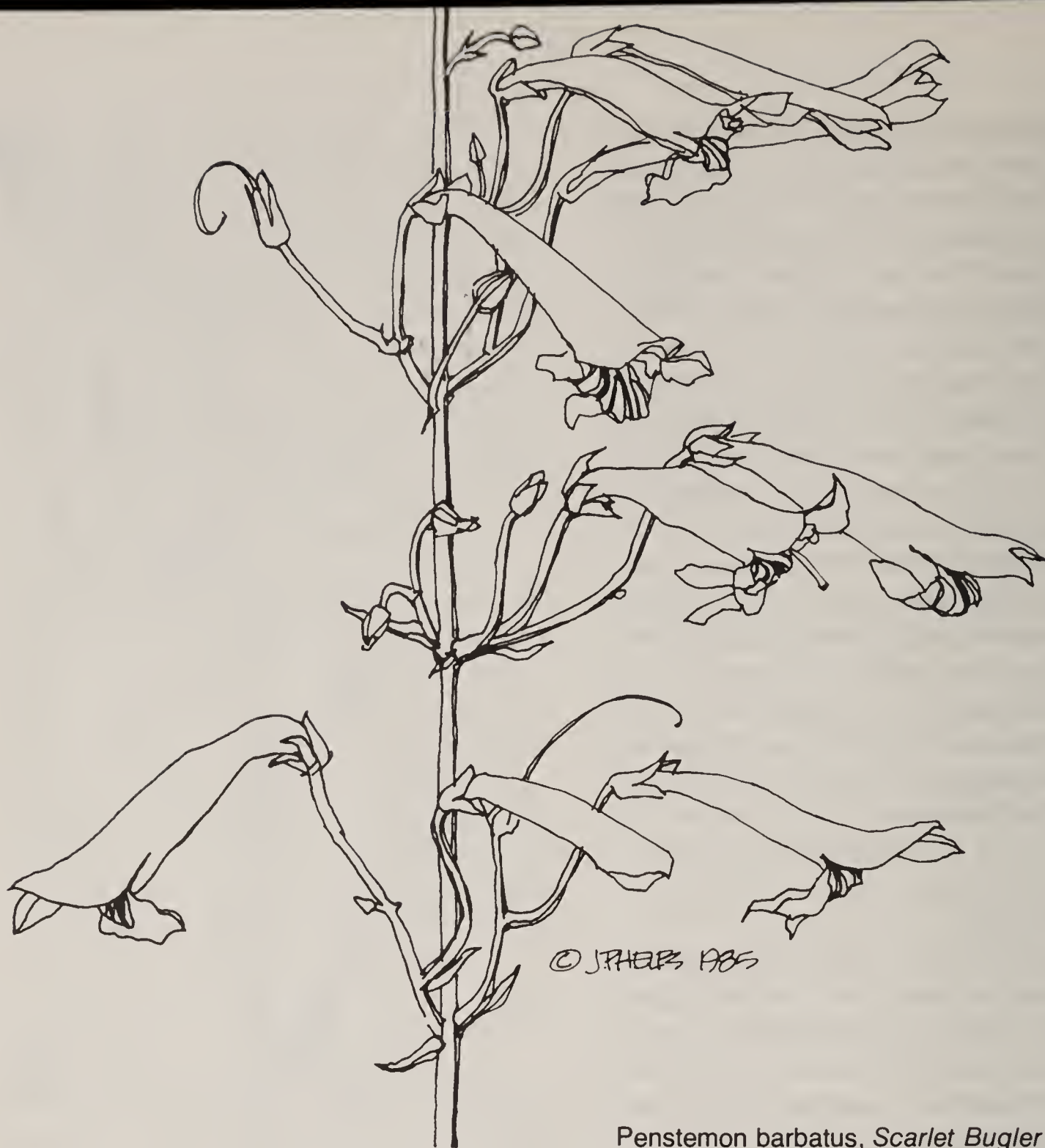


Lupinus sparsiflorus arizonicus,
Arizona Lupine

Figwort family

The figworts are a very large family; a typical member is the cultivated snapdragon. Several genera important in arid American landscapes are *Penstemon*, *Castilleja*, and *Maurandya*.

Penstemons are often called wild snapdragons, and there is certainly a strong family resemblance between the two. An almost countless number of penstemon species are known, and more are being discovered or segregated constantly. All are native exclusively to North America, most in the West, and virtually all are showy when blooming. They occur throughout a broad range of altitudinal zones. Most come readily from seed,



Penstemon barbatus, Scarlet Bugler

though many species require that the seed be stratified (exposed to conditions simulating winter).

The red-flowered species, *Penstemon barbatus* (Cav.) Roth, scarlet bugler, and *P. eatonii* Gray, firecracker penstemon, occur in the Southwest, the latter coming into our state in the Four-Corners area. Visitors to Mesa Verde National Park will perhaps remember having seen it there. These two are especially interesting because their principal pollen vector is the hummingbird. Scarlet bugler grows quite tall; a yellow form, equally attractive, also occurs. Another brilliantly red penstemon is *P. utahensis* Eastw., lower growing but no less beautiful. It occurs in Utah and in the Dolores River drainage of western Colorado. A handsome tall penstemon, *P. palmeri* Gray, native to northern Arizona as well

as Utah and California, has rose-colored and delicately fragrant flowers. Pink-flowered *P. ambiguus* Torr. occurs from the Great Plains west. It blooms quite late (July), and is about the same size as tall garden phlox, which it resembles.

Many penstemons are blue or bluish-purple. An especially beautiful robin's egg blue form of *P. angustifolius* Pursh occurs in the Black Hills of South Dakota. Another choice blue penstemon is *P. strictus* Benth.; the selected form, 'Bandera,' is particularly attractive.

Two excellent mat-forming species are *P. crandallii* A. Nels. from the San Luis Valley, and *P. aridus* Rydb. seen on dry, eroded hillsides in southern Montana. *P. aridus* has dark green, inch high, sharp foliage in tight clumps. When it blooms, it sends up a 4-inch stalk of small, deep blue flowers.

For a genus that is widely cultivated and can claim an international society of admirers, this enumeration is unforgivably brief. I would counsel arid gardeners to plant all the penstemons they can obtain—disappointment will rarely be their lot with any.

It would be difficult to find a more typical wild flower of dry grasslands than the Indian paintbrushes, genus *Castilleja*. *C. linariaefolia* Benth. is the state flower of Wyoming. Like the penstemons, they are typically western North American. The conspicuous part of the inflorescence of Indian paintbrushes is, in reality, colorful bracts with the true flowers concealed within. The bracts range from scarlet through brick-orange, to pink, yellow and white.

Much has yet to be learned about the ecology of Indian paintbrushes. They are certainly "social" plants in the sense that a single plant in a pot does not do particularly well; but give it a companion plant—almost any will do, even another paintbrush—and it becomes much more robust. Evidently involved is some kind of parasitism or mutualism. Propagation by seeds is preferred, and for most species stratification is required. This is another rich area for experimentation by gardeners.

Another genus in this family, *Maurandya*, has a vine-like habit. Only one species is of interest to us here: *Maurandya antirrhiniflora* Humb. & Bonpl., twining snapdragon. This figwort also has flowers like the garden snapdragon, as its common name implies. There are two color forms, one with lilac or pale violet flowers, the other with rose-red flowers. It is native from western Texas to California, including higher altitude areas of northern Arizona.

Lily family

The lily family, which provides so many showy flowers world-wide, is well represented in American dryland herbaceous flora. Its chief representatives are bulb plants belonging to two genera: *Calochortus* and *Allium*. Mariposa lilies, *Calochortus*, occur only in North



Castilleja sp., Indian Paintbrush

America, centering in California and spreading outward from there. The eastern limit is the westernmost Great Plains (e.g. the Black Hills). The sego lily, *C. nuttallii* Torr. & Gray, is the state flower of Utah, chosen because Mormon pioneers of that state saved themselves from starvation by digging them for food,



Calochortus nuttallii, Sego Lily

as Indians of the Great Basin had done from time immemorial.

These striking native "tulips" are of incomparable beauty; unfortunately, only a few are known to be of great hardiness. Native in Colorado and fully hardy in our area are *C. Gunnisonii* S. Wats. and *C. nuttallii*; both occur in the Great Basin and surrounding states, from Montana to New Mexico.

Mariposa lilies emerge from deep in the ground only during their growing and flowering season. By August (even earlier in really dry areas) they have completed their annual cycle, having produced a three-chambered capsule of yellowish, flaky seeds and retreated below ground to await the next spring.

The flowers, always with three large, overlapping petals, come in a number of colors, from deep rose or lavender through pink, orange, yellow, to white. The throat often has an intense, contrasting color. Each plant produces one or several flowers.

These lilies are not easy to grow. Propagation is by seed and several seasons' growth are required before flowering size is reached. Wild collected seed is available; the best method of propagation is to plant the seed in pots and care for them for at least two seasons. They then can be carefully removed and planted in the garden where the plants are to grow. The small bulbs will continue to grow and migrate downward until they reach the appropriate level. Gardeners who have produced several clumps of these plants can well congratulate themselves, for besides being beautiful, they are both uniquely American and quintessentially dryland plants.

The genus *Allium*, wild onion, is of world-wide distribution, and so well known that it requires little comment here. A great many species and forms are found in western North America, from desert to alpine zones. Most are dwarfs, only a few inches in height. They grow and bloom in the garden for years, as long as their needs are met. Their flowers are always a cluster of tiny, papery florets at the tip of a sometimes nodding, blooming stalk. Colors are those of other lilies—purple, red, orange, pink, yellow and white. There are no blue-flowered American species. Widespread in the Great Basin and surrounding areas is *A. acuminatum* Hook., with lavender to rose flowers. To be avoided is our commonest Colorado native, *A. cernuum* Roth, nodding onion, which can become very weedy. It typically takes over overgrazed pastures since it seeds profusely and stock will not eat it.

Evening-primrose family

The evening-primrose family provides one of the most common and typical genera of western American (and other) drylands. The genus *Oenothera*, whose com-

mon name is also evening-primrose, is an enormously large group—some annual, some perennial, some day bloomers, some evening bloomers, some large flowered, some small flowered, some mound forming, some shrubby. Virtually all are valuable dryland plants, both for their striking flowers and for their strong association with deserts. The flowers tend to be either a shade of yellow, white or light pink. They occur all over western North America, including the Great Plains and all of the western deserts.

Two large-flowered species available to Denver area gardeners, both native and abundant here, are *O. caespitosa* Nutt., an evening-blooming species whose flowers open white and turn to a soft pink as they age, and *O. brachycarpa* Gray, with rich yellow flowers. The latter species is

also an evening bloomer, and produces large, low colonies. Another local species is *O. serrulata* Nutt., a day blooming subshrub with small yellow flowers. Two others worth growing are *O. greggii* Grey and *O. lavandulaefolia* Torr. & Gray., also yellow-flowered subshrubs.

This is another group which should definitely be experimented with as much as possible, since many species have potential for cultivation here.

The other genus from this far-flung family I wish to recommend is *Zauschneria*, called variously hummingbird trumpet or California fuchsia. Both of these common names are very apt. Hummingbirds, the main pollinators of the *zauschnerias*—a fact predictable from their bright red, tube-like flowers—have played a major role in their evolution.



Oneothena caespitosa,
White-tufted Evening-primrose

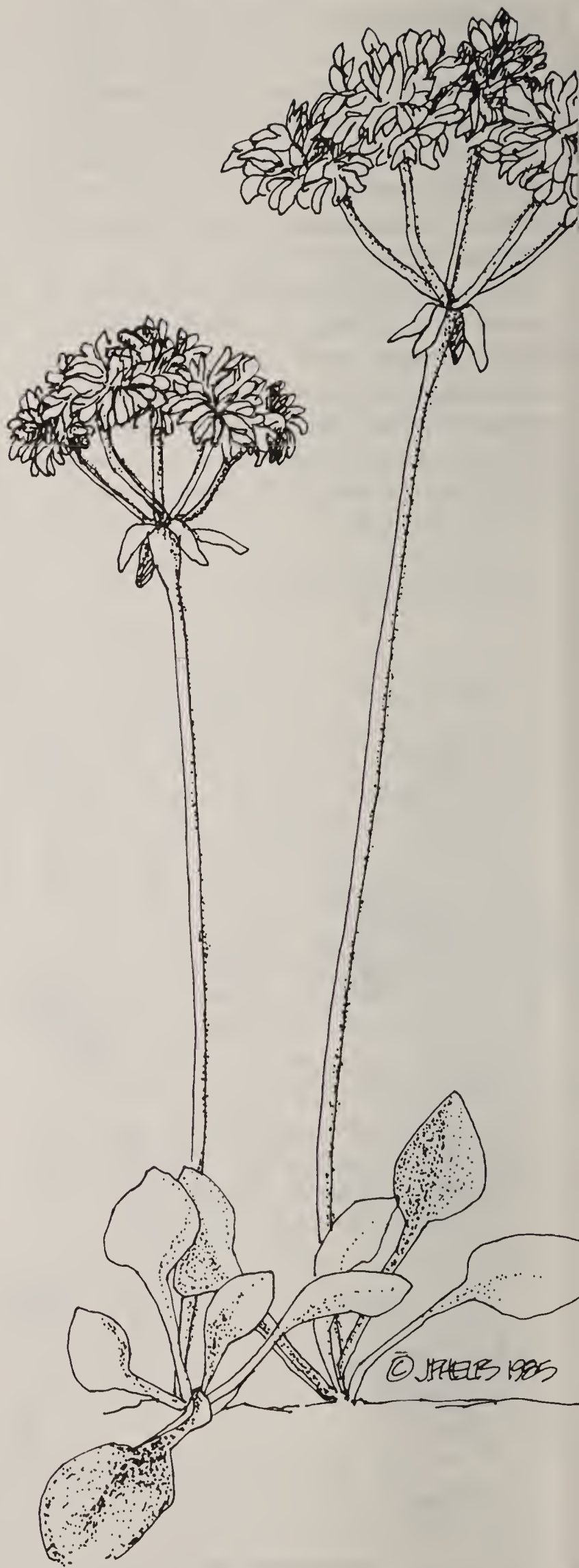
Also they are related to fuchsias and resemble certain of them.

The hardiest of the species is *Z. arizonica* A. Davids., forms of which succeed easily in our area. Unfortunately, this species is not as attractive as the less hardy *Z. californica* Presl. Forms of the latter that come from west of the Sierra Nevada are, in the main, sufficiently hardy; those from southern California are also very drought tolerant. I have one splendid plant which was started from a cutting; it dies to the ground each winter, but comes back larger each spring. It is a low growing, nodding shrublet covered with iridescent red trumpets in August and September, when many other plants have finished their flowering.

Buckwheat family

The buckwheat family contributes one genus, *Eriogonum*, common in western North America and occurring in all suitable dry habitats, from lowlands to alpine summits. There are well over 100 species; the plants themselves vary from tiny rosettes the size of a silver coin to giant forms which are virtually shrubs. Some are annual, but most are perennial. Of all the desert plants I know, this group, more than any other, bespeaks dryness. In many species, the living plant is typically dull in appearance—yellow, reddish, white or gray throughout, looking more like a dried plant than a living one. The flowers, too, may look more like a dried bouquet than like something alive. In *Eriogonum inflatum* Torr. & Frem., desert trumpet, the stalk is swollen just below the flowering scape, giving the plant a curious, bloated appearance.

The choice is very large here and generally of easy cultivation. Representative are *E. umbellatum* Torr., sulphur-flower, a lovely yellow-flowered native of our area, and *E. strictum* Benth. var. *proliferum* (Torr. & Gray) S. Stokes, a Great Basin native, powdery white throughout. Colony-forming *E. caespitosum* Nutt., develops huge mats composed of inch-wide, reddish rosettes. The flower stalk is also diminutive, rising barely an inch above the basal rosette. Native in our



Eriogonum umbellatum, Sulfur-flower

own area is another very attractive species, *E. effusum* Nutt., prairie baby's breath, a subshrub with reddish twigs and tiny white flowers in summer.

Phlox family

Another family that includes many attractive desert or drought-tolerant species is the phlox family. In addition to the phloxes, it includes the gilies, some annual or biennial and some perennial. The phloxes and gilies occur natively only in the Americas, principally in western North America.

It would be difficult to find a more typical cold desert plant than the phloxes; the genus is still in exuberant evolution, and virtually every cold desert environment, from western Canada south, and from foothills to alpine peaks, has its own endemic phlox. Low, twiggy, often prickly, the plants are very attractive even when not in flower. When blooming, the plant is all but hidden by the hundreds of pink, blue, or white fragrant flowers which completely cover it. Colorado has a multitude of native forms, from the high mountain parks to the plains. Most are best propagated by seed. Even high al-

titude forms do well in Denver. A choice western slope native is *Phlox austromontana* Coville; its flowers are white, pink, or bright lavender.

A quite different form of phlox occurs in the Chihuahua desert. In this group, the plant consists of 6- to 8-inch, rather weak stems. The flowers as usual, are star shaped, and appear at the tip of the growing stem. These phloxes, of which *Phlox nana* Nutt. is typical, are very untypical of the phloxes as a whole because of the color range of the flowers. While white, pink, and blue flowers are characteristic, this subgroup contains yellow, orange, and scarlet flowered species—the only ones in the family.

The center of distribution of this unusual group seems to be the Mexican state of Chihuahua, but all of the forms from there have proved to be perfectly hardy at Denver Botanic Gardens, where they have been a sensation for several years. Certain selected forms have been given clonal names at the Gardens where they are propagated vegetatively, primarily by stem cuttings. Large clumps of these phloxes in flower during the dry late summer and fall are even more ap-



Phlox austromontana, Desert Phlox

peeling because so few other plants—and none of their relatives—are blooming at that time.

A perennial *Gilia* of great charm is *Gilia rigidula* Benth., blue gilia. An elaborately branched shrublet with bright blue flowers, it is native in southeastern Colorado, as well as regions to the south.

Mallow family

The mallow family has many species, distributed world wide. Familiar to most gardeners are hollyhocks, lavateras, and hibiscus; also belonging to this family are the economic plants, okra and cotton.

Of interest to the arid gardener here is virtually only one genus, *Sphaeralcea*, globe mallow. The most familiar species in our area is *S. coccinea* (Nutt.) Rydb., cowboy's delight, occurring from the Great Plains to California. It produces miniature orange hollyhock-like flowers along the stem, the oldest at the bottom. The seeds are also identical in appearance to those of the hollyhock, though much smaller. A number of other species occur throughout the West, all variations on the dwarf hollyhock pattern. Flower color in the different species varies from red, pink or lavender to orange and white.

An even brighter mallow is *Callirhoe involucrata* (T. & G.) Gray, wine cups, or poppymallow. This plant, primarily a Great Plains native, grows up to 2 feet tall, producing at the end of each stalk a large deep rose to red upward-facing flower, superficially like a hibiscus. It is almost too exuberant for a desert garden, but its flowers can contribute much-needed summer color in arid plantings, which inevitably are at their best in the spring.

Loasa family

To the loasa family belong the *Mentzelias*, called evening-stars. The non-botanically inclined usually dislike the evening-stars because they are sharp and prickly, and stick to clothing which brushes against them. Some are annual, some biennial, some perennial. The plants are everblooming; the flowers

open in the late afternoon, a trait which gives them one of their common names. Flower color in the mentzelias ranges from white to deep yellow or orange. The blossoms of the larger-flowered forms are quite striking: they greatly resemble the flowers of the *Cereus* group in the cactus family.

Several species of *Mentzelia* are fully winter hardy. Most impressive locally is *M. decapetala* (Pursh) Urban & Gilg whose creamy white flowers are up to 6 inches in diameter. The flowers of *M. speciosa* Osterh., also local, are a combination of white, lemon and golden yellow. Other desirable species are *M. pumila* (Nutt.) Torr. & Gray, a yellow-flowered form from New Mexico, and *M. laevicaulis* (Doug.) Torr. & Gray, with chrome-yellow flowers from Nevada. This genus is one that deserves extensive experimentation.

Vervain family

The vervain family contributes only a few species to the arid garden. Of greatest interest are pink-flowered *Verbena goodingii* Briq., hairy verbena, native in the eastern Mojave Desert and surrounding areas, and lavender-flowered *V. ambrosiifolia* Rydg., a local species found on the plains and in the foothills. Another species, *V. wrightii* Gray has flowers that vary from pink to magenta. It, too, is well worth planting, if it can be obtained.

Borage family

An extremely important part of our western flora is the borage family. To this family belong, for instance, the beloved alpine forget-me-nots, whose brilliant blue makes high alpine slopes look like a bit of fallen sky. Not all members of the family favor dry habitats, but many do. Three genera are worth mention.

Many species of very desirable plants belong to the genus *Cryptantha*, which occurs only in the Americas. The typical *Cryptantha* has hairy leaves and stems giving these structures a dull gray appearance. The flowers of the cryptanthas are usually white, though some yellow-flowered forms also occur. The shape of



Mentzelia pumila, Evening-star

the flower, and the inflorescence itself, look almost like a forget-me-not. A common local species is *C. jamesii* var. *cinearea* (Greene) Payson, a low gray plant that opens its glistening white blossoms in early spring.

To the genus *Lithospermum* belongs an interesting group of yellow-flowered plants; *L. incisum* Lehm., narrow-leaved puccoon, is typical. Also an early bloomer, this locally abundant plant has long-tubed yellow flowers that look superficially like cryptanthas.

A group of plants ordinarily associated with moist habitats in the high mountains, mertensias also have a very attractive lowland representative. *Mertensia lanceolata* (Pursh) A. DC., narrow-leaved mertensia, appears in the foothills during mid-spring, its diminutive clumps look-

ing exactly like the much taller stream-side chiming bells of higher altitudes.

Mustard family

The mustard family including such familiar north European plants as cabbage, turnip, radish and kale seems an unlikely one to be represented in dry, hot areas. Yet, at least three genera of this family are of interest for a desert garden in our area, since all contribute to the native flora of dry regions of the west. Least like the other two is *Stanleya*, represented by *Stanleya pinnata* (Pursh) Britt., prince's plume. This tall, yellow-flowered forb, producing spikes of flowers in early summer, blooms from the bottom of the spike upwards, so seed pods and immature flower buds are present at the same time. It occurs throughout the West

in dry localities.

The other two genera are *Physaria*, twin-pod or double bladder-pod, and *Lesquerella*, bladder-pod. Members of these genera are all low plants with 4-petaled, yellow flowers. The dried flower stalks with the attached fruits (siliques) are also attractive.

Physaria is represented in our area by *P. vitulifera* Rydb. and *P. bellii* Mulligan, the latter restricted to a small area of shale barrens north of Boulder. Double bladder-pods are flat rosette plants reminiscent of a sempervivum, the leaves somewhat fleshy and blunt. The flower stalks arise from among the leaves, forming a loose spray. Bladder-pods occur widely throughout the West in a variety of forms—tall, short and tiny. The basal rosette is typically evergreen. Two local species, *Lesquerella ludoviciana* (Nutt.) S. Wats., silvery bladder-pod, and *L. montana* (Gray) S. Wats., mountain bladder-pod, are both worthy of cultivation. Both *Physaria* and *Lesquerella* species should be propagated by seed.

Two rather large magenta-flowered forbs belonging to two quite different plant families occur in Colorado (one in the environs of Denver): *Ipomoea leptophylla* Torr., bush morning glory, and *Mirabilis multiflora* (Torr.) Gray, giant four-o'clock. Both are excellent subjects for the dry garden. The family affiliation of these showy plants is indicated in their common names. Though many gardeners shudder at the mere thought of a morning glory in their gardens, bush morning glory, a handsome Great Plains native, remains well within bounds and is not a pest. The giant four-o'clock is native to the warm regions to the south of us, but it occurs as far north as the Arkansas River Valley in Colorado and is not difficult to grow in Denver. Both of these plants are easily propagated by seed, although those of bush morning glory require scarifying.

Succulents

Two families, the purslanes and the stonecrops with characteristically succulent leaves, contain many suitable perennials for the arid garden.

The genus *Lewisia*, of the purslane family and named for Meriwether Lewis of the Lewis and Clark Expedition, includes some of the most beautiful flowering plants of any succulent group. The lewisias have a thick succulent root that produces a new crop of succulent leaves and flowers each year. After blooming and fruiting (in effect, when summer drought sets in) the leaves dry up and disappear, leaving no visible trace of the plant. This cycle of short above-surface growth and long below-surface rest goes on for years for each individual plant.

Most typical of the genus is *L. rediviva* Pursh, bitterroot, the state flower of Montana. The medium large, satiny flowers of this plant vary from a whitish-pink to deep rose. Several other lewisias occur throughout the West, including some handsome ones from dry microclimates in the Pacific Northwest, e.g. *L. tweedyi* (Gray) B.L. Robins. All of the lewisias certainly have a future in dryland gardens in our area.

Another genus of interest here is *Talinum*; most occur in the southern Great Plains and the dry Southwest. Like the lewisias, the talinums are deciduous. Best for our area is *T. calycinum* Engelm., a rounded, much branched plant with dozens of purple-pink flowers opening only in bright afternoon light. Each flower lasts several days, alternately opening and closing. *T. calycinum* is one of the most dramatic plants in existence, since it scarcely merits a glance outside the flowering season or when the flowers are closed. But when the right moment arrives on a warm afternoon during the flowering season, a very ordinary plant becomes simply overwhelming.

Other desirable succulent plants belong to the stonecrop family. This group is basically tropical or subtropical. Nevertheless, natural selection on our huge continent has produced some hardy forms. The diminutive *Sedum lanceolatum* Torr. grows in Colorado from the foothills into the subalpine zone on poor, dry, largely acid soils. This tiny plant turns red or orange when dry or cold, but is plump and green when plenty of water

is available. In the spring, it produces a short 1- to 2-inch stalk topped by a cluster of brilliant yellow flowers. This plant dies after blooming.

Ferns

For final consideration I have reserved a plant group which is easily one of the most fascinating, but also, unfortunately, the most difficult. These are the desert ferns, which enhance their native habitat both by their beauty and by the striking contradiction of their presence in the hot, dry environment of the desert.

The American deserts have many species of ferns which have undergone extensive adaptation in order to survive there. Most are quite farinaceous giving them a silver or white powdery appearance, a trait they share with many other desert plants; the farina protects the plants from heat and water loss. Another trait that some desert ferns exhibit, in common with many of their relatives, the mosses, is to curl up tightly as water is lost. They remain tightly curled until water returns, when they unflurl and resume their interrupted lives.

I do not recommend planting the desert ferns, since their extreme specialization dooms them to almost certain death in the garden. I mention them, rather, to alert the arid plant enthusiast to their existence, and to urge him or her to watch for them when exploring or hiking in the desert. Enjoy them there until commercially propagated plants become available.

I have not had particularly good luck with desert ferns; it is possible to succeed, if at all, with very small plants only. A larger plant almost always dies when planted in the garden. They should be placed among or, better, below rocks where moisture is available longest. Colorado has several desert ferns belonging to three genera: *Notholaena*, cloak fern; *Pellaea*, cliffbrake; and *Cheilanthes*, lip fern. All three of these occur around the state in dry sites such as cliff faces. Phantom Canyon near Cañon City is one area rich in these ferns. Other places are Owl Canyon west of Fort Collins, and Flag-

staff Mountain just west of Boulder. Such success as I have had has been greatest with *Cheilanthes feei* T. Moore and *Cheilanthes fendleri* Hook. These small ferns with their brittle, triangular, short fronds, are very much at home with prickly pear cactus, whose habitat they share both in nature and in my garden. They are very charming, discreet neighbors of the more robust plants which surround them.

Reference Resources

The primary printed source of ideas for the cultivator of species plants is regional floras, and any serious gardener of this genre must learn to use them. For native western plants, floras of Colorado, New Mexico, Texas, Arizona, California, Nevada, Utah, and others, are available, as are studies which treat larger (e.g., Great Basin) or smaller areas (e.g. particular national parks). Good references are also available by type of plant, e.g., trees and shrubs, or wildflowers. These monographs are easy to locate in good public or university libraries. Many are available from the Helen Fowler Library of Denver Botanic Gardens.

Users of floras should keep in mind that their arrangement is according to taxonomic principles, which use primarily (or even exclusively) botanical terminology. This special vocabulary will have to be learned. A source of great additional frustration to the non-professional (and even to some professionals!) is the fact that not all writers use the same scientific designation for the same plant. This stems from both genuine disagreement between authors as to what a plant "really" is, and to separation in time between the writers. It is a good idea to check several handbooks for the same plant, since the various indexes may help resolve difficulties of this kind.

For a discussion on sources of plant materials, see *Desert Gardening in the Denver Area*, Part I, *The Green Thumb* 42 (2):36-37.

Following is a list of handbooks which I have found to be very useful.

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The author would like to thank Mr. James Borland and Mr. Panayoti Kelaidis, both of the Denver Botanic Gardens staff, for many helpful suggestions in the preparation of "Desert Gardening in the Denver Area."

"Desert Gardening in the Denver Area: Part I" covering trees, shrubs, succulents and sclerophylls appeared in *The Green Thumb*, summer 1985. Our apologies to the author as well as the readers for the errors. Dr. Taylor's name is Allan (not Allen as it appeared on the contents page). On page 49, column 1 the first sentence of the first full paragraph should read: Another quite hardy agave in the *A. Utahensis* Engelm. complex which occurs from the Kaibab Plateau north and west to (not of) the Charleston mountains. . . .

—Editor

FOCUS ON *Ficus religiosa*, IN THE BOETTCHER MEMORIAL CONSERVATORY

by Peg Hayward

Ficus religiosa Linn., bo tree, sometimes called peepul tree is native to India and is of particular religious significance to both Hindus and Buddhists. The Hindu divinity, Vishnu, is believed to have been born under a bo tree; and it was under a bo tree that Guatama Buddha meditated for 6 years and received enlightenment.

These trees are often planted beside temples and in front of houses to assure prosperity and happiness to owners. Because the tree is considered sacred by the Hindus, to cut a tree or its branches is to them as wrong as to ill-treat one of the sacred cows.

The bo has a very long life. There are

records of a tree taken to Ceylon from Northern India in 288 B.C. At the end of the last century the tree was still living. In 1852 it was known to be 2147 years old.

Bo trees reach very large proportions. With grayish-brown irregularly fluted trunks and wide spreading branches, a bo tree may reach a height of 80 feet and attain a spread of about 100 feet. The most distinctive characteristic is its foliage. Alternate leaves are borne on slender petioles and the slightest breeze sets them quivering like the leaves of aspen trees. Leaves are oval in shape, narrowed at the apex into a long tail; the base is heart-shaped. The tree is deciduous but loses its leaves only for a short time. Young leaves may be of various shades of pink and green. At maturity they are a rich shining green above, paler beneath.

Peg Hayward, long associated with the guide training program for Boettcher Memorial Conservatory, writes "Focus On" as a regular feature of *The Green Thumb*.

Receptacles or figs come in pairs at the angle between the leaf stalk and the branch. The figs are about $\frac{1}{4}$ inch in diameter, green at first, turning purple-black when ripe. Each receptacle contains both male and female flowers mixed with lanceolate bracteoles. The real fruits, as in all fig trees, are the tiny pips, which may be seen when the fig is split open. The figs of the bo are eaten in times of famine. Birds are very fond of the fruit and the indigestible seeds pass through their digestive tract and are scattered around the country. Under sufficiently moist conditions, the seeds often germinate on roofs, cracks in walls or on other trees so in its young stages the bo may be epiphytic.

Besides being held in veneration by the people of India the bo tree provides great

shade. Leaves, bark and fruit are used in native medicine. The bark yields a tenacious milky juice which hardens into a substance resembling caoutchouc. Also, when boiled, the bark yields a dye of a reddish-fawn color. The leaves are used by art hobbyists. When skeletonized (chlorophyll and other cells removed leaving only the veins) they may be dyed or painted to make bookmarks, greeting cards, flowers and other handicrafts.

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Ficus religiosa—Bo Tree

The Botany Club of Denver

by Marjorie L. Shepherd

A meeting was held on June 7, 1955 in Room 37 of Old Main on the University of Denver campus, courtesy of Moras L. Shubert, Ph. D., professor of botany. This was officially the organizational meeting for the formation of a botany club. What had been the preparation for it?

During the decade of the 40s, there was an organization called Colorado Seminar in Botany. This was headed by Harold D. Roberts, a prominent amateur wildflower photographer, as president. Joseph Ewan, then a student at the University of Colorado and, since, the author of *Rocky Mountain Naturalists*, was editor of the monthly bulletin. I had the pleasure of seeing a file of this bulletin which was in the possession of Mrs. Katharine Bruderlin Crisp, botanist and participant in the seminar. I remember that many of the stalwarts of the Colorado Forestry and Horticulture Association were among the group active in the seminar.

Marjorie L. Shepherd was instrumental in getting the Botany Club off to a good start, and served as the executive secretary from its beginning until its demise 30 years later. She first became interested in plants as a child through the influence of her mother and older sister, who were greatly interested in plants. Mrs. Shepherd has been a volunteer in the Kathryn Kalmbach Herbarium since 1970. Because of her knowledge of native plants she has been a very valuable volunteer and field trip leader, with a special interest in leading trips to alpine areas.

HMZ

One of the members of the seminar was Ernest H. Brunquist, Ph. D., who was also active in Colorado Mountain Club. He was the leader for their flower trips, popular since they required no special mountaineering skills. Upon joining the Mountain Club in 1948, I met Dr. Brunquist and enjoyed his trips, thus extending the interest in botany I had developed in the East before migrating to Colorado. When I was introduced to the fact that flowers differed as altitude was gained in ascending the mountains, it was a whole new world. Especially, I fell in love with the tiny plants above timberline.

As time went on, Dr. Brunquist wanted to form a botany study group and asked me to join forces with him. We began to build a mailing list by starting with names of people who had attended the Mountain Club flower trips.

In July 1954, there was a trip to Loveland Pass, perhaps sponsored by Colorado Forestry and Horticulture Association. Dr. Shubert and M. Walter Pesman were there. We were joined by William A. Weber, Ph. D., with some of his students from the botany department at the University of Colorado in Boulder. During lunch we discussed the organization of a botany club. Dr. Weber said, in effect, that there were not enough professionals to cover the diversified ecology of Colorado and he, for one, would like to see a club started. He recognized that a valuable contribution could be made to a more complete knowledge of the flora of the



Botony club field trip near Bailey. Dr. Brunquist and Mrs. Shepherd are in the foreground.

state by many interested amateur botanists.

We continued to collect names and by spring of 1955 felt we had an adequate nucleus to proceed. Dr. Brunquist prepared a flier titled "It's in the Bud, a Botany Club" announcing the meeting. Seventy-five announcements were mailed. The meeting on June 7, 1955 was attended by 18 persons, and 12 others indicated interest but could not attend. We had expected to have the club under the wing of the Colorado Mountain Club. However, since a majority at the meeting were members of Colorado Forestry and Horticulture Association, our regular meetings began at Horticulture House in September.

By 1957, we were having regular monthly meetings and field trips. The summer meetings concentrated on identifying plants collected on the weekend field trips. Dr. Brunquist had a special affection for the plains flora and often brought in some unusual and beautiful flowers from that area to be studied at

meetings. The winter meetings included studies in basic botany as well as speakers and slide shows on botanical topics.

One meeting in particular was the beginning of a tradition. On March 3, 1957, H. D. Harrington, Ph. D., from Colorado State University and author of the then newly published *Manual of the Plants of Colorado*, came from Ft. Collins and some of us took him out to dinner. His subject at the meeting was "How Amateur Botanists Can Help in Projects." He distributed a list of plants which had not been collected in Colorado but were likely to be found. He anticipated that, with more interested persons aware of the possibilities, more plants would be discovered and added to the records of Colorado flora.

For many years an annual dinner meeting was held in March with the best of speakers presenting pertinent and interesting topics. Among them were Dr. Weber; John W. Marr, Ph. D., plant ecology professor at the University of Colorado; Beatrice Willard, Ph. D., who

studied and has written extensively about alpine ecology; Ruth Ashton Nelson, author of several regional floral keys, the first being *Plants of Rocky Mountain National Park*, published in 1933; and John Long, M.D., amateur botanist with a special interest in the orchids of Colorado.

The dinner meetings were discontinued when many of the members felt they were too costly. The regular meetings were moved to Denver Botanic Gardens House in 1959, and after completion of the Education Building we met there. In recent years we continued with plant identification at summer meetings, and in winter we had beautiful slide shows. We "traveled over the world" seeing flower photography at its best. During the many years I arranged those meetings I rarely met with a refusal. I wish I could list and thank the many, many persons who helped; it would be a very long

list and would include many who supported the club but did not attend meetings.

Dr. Brunquist died in 1978 and in the years since, attendance at the summer meetings dwindled to just a faithful few interested in plant identification. After three decades of having much of the responsibility for the club, I began to look for a successor. Coincidentally, in 1984 the Colorado Native Plant Society, an organization with similar interests and purposes, formed a Denver-Metro Chapter.

In January 1985, at my request, a representative of that group attended the Botany Club meeting and extended an invitation to the members to join the Colorado Native Plant Society as a fitting alternative to continuing the Botany Club. Thus ended thirty memorable years of the Botany Club of Denver.



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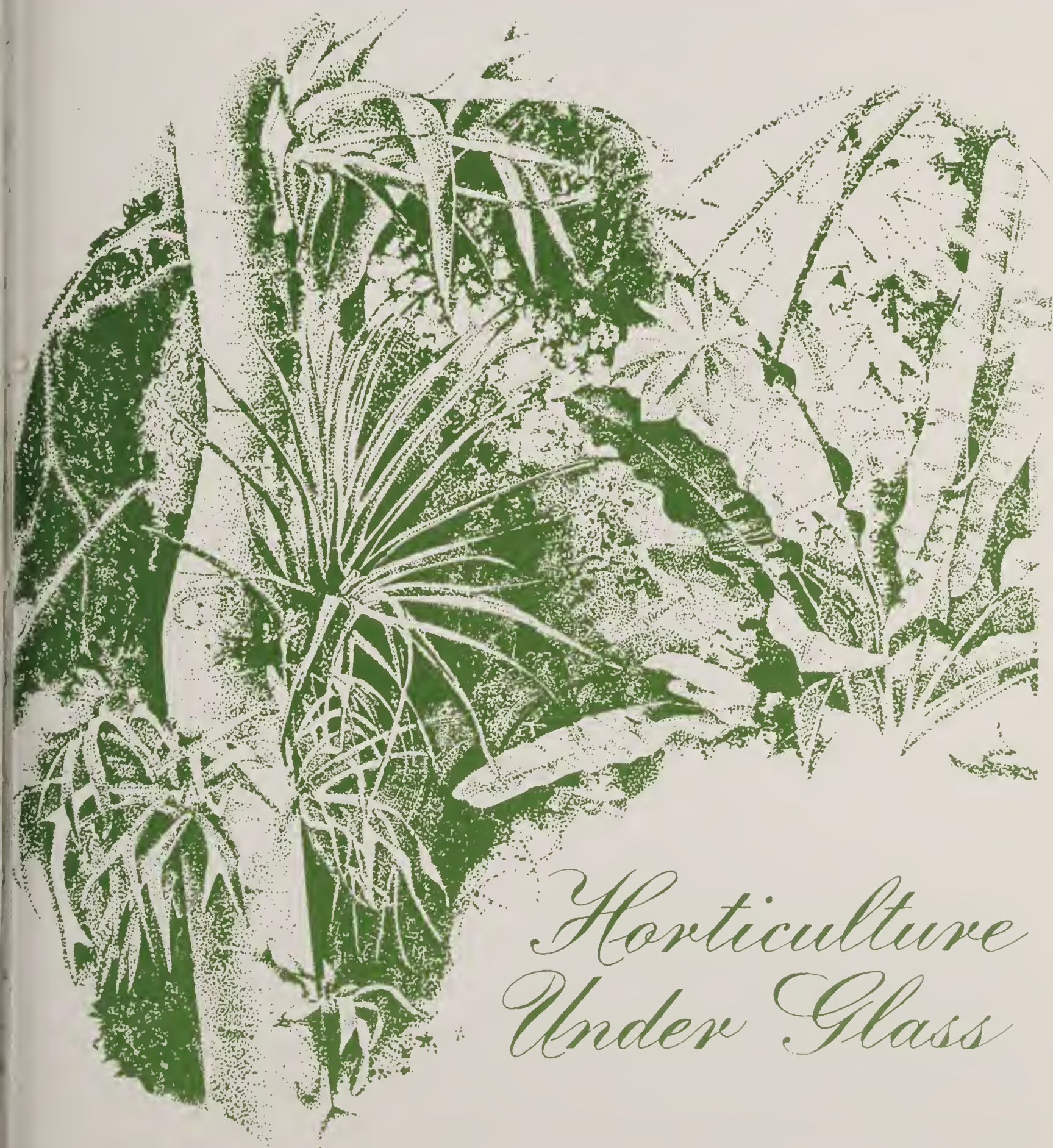
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Volume Forty-two
Number Four



*Horticulture
Under Glass*

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Horticulture Under Glass

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The Green Thumb

Winter 1985

Velma A. Richards
Editor

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Denver Botanic Gardens, Inc., maintains a collection of living plants, both native and exotic, for the purpose of acquiring, advancing and spreading botanical and horticultural knowledge.

This is a non-profit organization supported by municipal and private funds.

Extraordinary Houseplants for Ordinary Houses

by Larry Latta

Plant lovers often express their desire for "something different." Jaded by jade plants from South Africa, monsteras from Mexico, aloe veras from south of the Mediterranean and gold dust trees from the Orient, we search for plants even more exotic, new subjects for our insatiable horticultural appetites.

But novelty alone, even strikingly adorned, does not suit a plant for everyday life in our everyday homes. It must also possess the fortitude to withstand the often negligent and sometimes hostile physical conditions it will find within our doors. From among the vast number of plants gathered from distant corners of the tropical and subtropical world to flourish in our greenhouses and conservatories, many have had outstanding floral or foliage beauty. But could most be recommended as house plants?

Here are a few that can. Of the plants that we have observed in our collections, these, previously little used, seem to possess the prerequisites for home growing: They have attractive foliage, flowers or growth habit and they are durable and adaptive to environments similar to those found in most houses. Most importantly, they are not particularly rare; responsive florists could easily meet con-

sumer demand.

Consider *Abutilon megapotamicum* St. Hil. & Naug. 'Variegata' from South America; it is of much tidier growth habit than the other flowering maples which you may know. (None is closely related, of course, to true maples of the genus *Acer*.) This woody-stemmed plant has bright yellow and green mottled foliage, pendant red and gold lantern-like blossoms and an attractively drooping posture which makes it suitable for growing in a hanging basket or a planter box. More floriferous in sunshine, it will also catch your eye in semi-shade because of its colorful foliage. It needs constant moisture and frequent fertilization to maintain active growth.

One of the small-leaved begonias could and should be grown in every home along with the larger-leaved "angel wing" types. Attractive the year-round, *Begonia fuchsioides* Hook. is especially recommended for its brilliant red pendulous, tear-drop flowers. A compact bush with arching stems clothed in glossy half-inch leaves, its native habitat is also in South America. Other attractive plants of this tiny-leaved group are *B. echinosepala* Regel, a Brazilian species whose ovaries and white sepals are studded with prickly hairs, and from the northern Andes, *B. foliosa* HBK, which forms a dense, feathery shrub. Any of these three begonias will charm you not only with its attrac-

Larry Latta, botanist-horticulturist, is responsible for the Horticulture Under Glass department at Denver Botanic Gardens.



Abutilon megapotamicum 'Variegata'—Flowering maple.

tive grace but with its pest free nature; its only requirements in return will be to occupy a bright spot in half-sunshine and to have perfectly porous, fast draining soil.

From Mexico comes a slender, woody shrub with attractive twice-pinnate leaves and 2-inch flower heads of scarlet blooms, *Calliandra emarginata* (Humb. & Bonpl.) Benth., the dwarf powder puff tree. It should blossom all through the year in a sunny window and can tolerate some shade. Somewhat winter-deciduous in nature, it needs regular watering to keep it evergreen in your home where it will slowly reach a height of 4 feet and assume the graceful form of a miniature tree.

Euphorbia fulgens Karw., known as scarlet plume, is of the same genus as its Mexican compatriot, the common Christmas poinsettia, but its habit is altogether more graceful. This plant is extremely long-blooming; small flame red "flowers" (actually bracts) adorn the length of its willowy, arching stems from Christmas into early summer. There may be up to 20 stems on a gallon-size plant and these may reach 3 feet in length dur-

ing a good growing season. They should be cut back severely after blooming to promote branching and flower production, or they may be cut earlier and used as long-lasting flowers for arranging. Bright light, ample water, a very well-drained soil mixture and, from spring through fall, regular fertilization are its major cultural requirements.



Calliandra emarginata—Dwarf powder puff.



Felicia amelloides 'Variegata'—Blue marguerite.

Long-stalked sky-blue flowers above small sage-green leaves heavily variegated creamy white certainly set *Felicia amelloides* (L.) Voss 'Variegata' apart from run-of-the-mill houseplants. You may use it anywhere you have had success with a windowsill geranium; it likes sun and thrives with cool nights. It quickly becomes root bound, so watchful watering is in order. Known as the blue marguerite, it can be kept as a dense 15-inch ball by shearing it in early spring. Use the clippings to start new plants, if you wish, as summer annuals in the outdoor garden.

If you like fuchsias but don't like to contend with their perennial nemesis, white fly, you will be doubly attracted to *Fuchsia triphylla* L. It is amazingly free from this pest (though, not totally immune under stressful conditions) and has other attractive attributes as well. The tops of its velvety dark green leaves are veined with maroon and the undersides are entirely maroon. This forms a dramatic background for the scarlet, 2½-inch pendant flowers which grace the tips of its branches. As with all fuchsias, this one needs to be kept moist and regularly fertilized the year around. Since it is from Haiti and the Dominican Republic it

doesn't require the cool temperatures demanded by most of its genus and should bloom well if given a bright, not necessarily sunny, spot in your house.

Fragrance! Too few houseplants offer it. But a small, glossy-leaved plant from South Africa named *Mitriostigma axillare* Hochst. has fragrance in abundance and its starry inch-long, blush-pink flowers appear in profusion throughout the year. Further, it does not need the sunniest of locations to perform for you. Keep it well watered in porous soil, fertilize regularly and watch it slowly become an attractive, much-branched, 15-inch shrub. *Mitriostigma*s grow in many gardens in the South where they are mistakenly called *Gardenia citriodora* Hook. As subjects in our indoor collections in the North they are more pleasantly scented and much more dependable than the true gardenias, which are notoriously adept at dropping their buds just before they open.

An oak indoors? *Buddleia indica* Lam., formerly known as *Nicodemia diversifolia* Tenore, is a shade tolerant tropical plant with beautifully glossy, dark green oak-leaf-shaped foliage. This alone is enough to recommend it over the all-too-common schefflera. It forms an attrac-

tive shrub wider than high with branches arching gracefully outward. A native of the island of Madagascar, it thrives in the same low light levels as many of our old standbys and is tolerant of a wide range of soil and watering conditions.

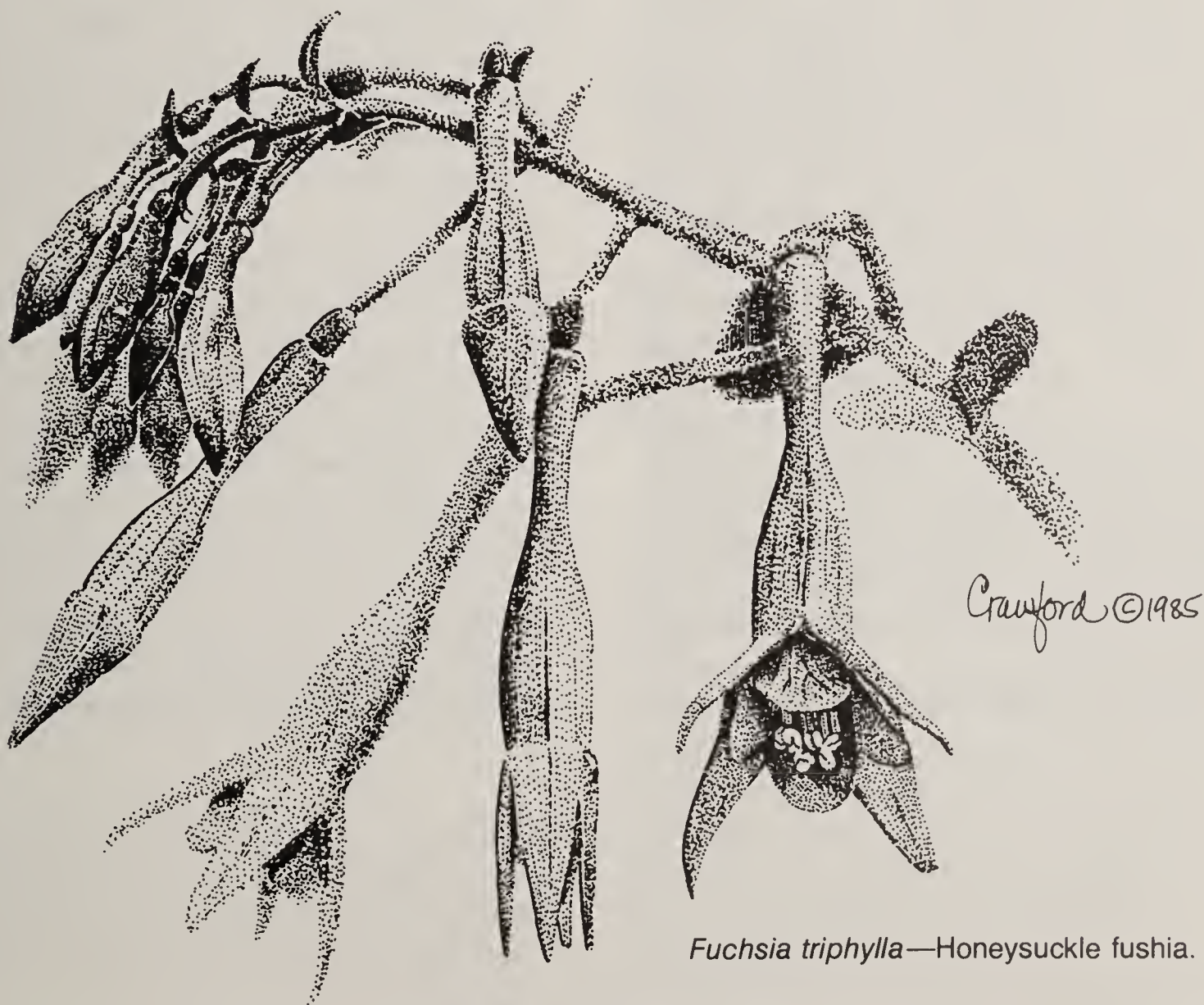
Rondeletia leucophylla HBK, from Mexico, a free-blooming 4-foot shrub with 2-inch heads of deep pink flowers, is much easier to coax into bloom than other popular flowering houseplants such as hibiscus. It could be kept sheared to 2 feet which would encourage more blossoms and new growth clothed in woolly white hairs. This plant should be chosen for a bright, semi-shaded situation where it should be kept moist and fed with a low-nitrogen fertilizer about every fourth watering.

Another easy-to-bloom and, unfortunately, under-used plant is *Ruellia makoyana* Hort. It is ideal for a semi-shaded spot back from the window. If you can imagine small bright carmine blossoms nestled among purple leaves with light pink midribs, you can certainly picture a spot for this one in your home. Its stems trail slightly, making it suitable

for displaying in a hanging basket or pedestaled cachepot. If kept moist and given a loose soil this Brazilian beauty will brighten any plant room.

The pepper vine, *Piper nigrum* L., does well as a houseplant. It has many of the features that have made *Philodendron oxycardium* Schott a favorite for years: it has deep green leathery, heart-shaped leaves, grows well in dim light, is nearly pest-free, and requires almost no attention. Planted in porous soil and watered frequently, it quickly makes a much bushier vine than the philodendron. Pepper is native to the Old World tropics and shares with many other members of its family the habit of exuding pinpoints of sugary liquid on the tips of its pungent leaves. A growth of gray mold may occur on the exudate, but showering the foliage regularly prevents the mold, which is not attacking the plant, from becoming a problem. It remains a favorite and an attractive candidate for the adventuresome gardener.

Because of its easy culture and outstanding flowering habit, one small bromeliad must be mentioned in this list



Fuchsia triphylla—Honeysuckle fushia.

of super-performers. *Tillandsia ionantha* Planch., an adaptable species widespread in the American tropics, is a true miniature. Its stiff, sharp 2- to 3-inch leaves circle in a tight rosette no larger than 5 inches tall; over the years it forms a cluster of plantlets suggestive of a silver-green hedgehog. When it blooms this plant wins over the last doubter: in the center of each of the most recently matured plants of the cluster the leaves turn bright red, and a succession of intensely blue flowers, over an inch long, emerge in brilliant succession. To achieve this yearly display, grow this tillandsia as the strict epiphyte it is. Mount it on a cork plaque or scrub oak branch, by stapling, tying or gluing. Place it in a sunny spot, water once a day during its growing season (late spring through fall) and fertilize rarely with a very diluted solution. Water it less often the rest of the year.

At first, a garlic-scented plant may seem a strange choice for a houseplant, but *Tulbaghia violacea* Harv. produces such a profusion of lavender pink flowers it deserves consideration. The dainty blossoms are borne in airy heads atop 24-inch stems, yet its neat linear foliage—typically, bluish-green and, yes, garlic scented, but only when crushed—is only about 10 inches tall. The leaves of a lovely variegated form sometimes marketed under the varietal name 'Silver Lace' are bordered in white; and are especially attractive. Although tulbaghias bloom most intensely during the summer, a full 6-inch pot could have blossoms throughout the year, with a brief lapse during November and December when it should be allowed to rest, nearly dry. At this time you may divide it and use the surplus for outdoor summer annuals. When actively growing, bright light, constant moisture and frequent fertilizing are in order.

Let's end this brief list with a bulb-

plant not only beautiful and easy to grow, but fun as well. *Zephyranthes grandiflora* Lindl. is a houseplant you can play with. The zephyranthes, mostly from the subtropical regions of the Americas, are called rain lilies because of their habit, after a period of drought, of immediately emerging from dormancy to burst quickly into bloom upon the advent of a rainy spell. Response to changes in their environment is amazingly quick and they are capable of repeating this feat several times a year. This makes it possible for you to manage your plant's blossoming to suit your whim. After an adequate period of active growth, merely withhold water until the grassy leaves wither. Subject the bulbs to a strict dormancy of at least two weeks. Then, about three weeks to a month before you want the plant to bloom, water the potted bulbs thoroughly and place the pot in a bright window. Keep it well watered and fertilize it regularly with a low-nitrogen solution for several months to rebuild its resources and you are ready to manipulate its cycle again. The flowers? They are bright pink, tubular, about 2 inches across on 10-inch stems; they alone are worth the cultivation of this unusual little plant.

The selection listed here is necessarily short and not necessarily rare. It is, however, purposely personal, as is your search for "something new" in houseplants.

To find these out-of-the-ordinary plants, search through the excellent collection of mail-order catalogs in the Gardens' Helen Fowler Library. Sources for most of the plants can be found there. Several have been offered in the past as free benefits to members of the Gardens through our annual Membership Plant Distribution program. Still others will be offered in the future along with other interesting subjects, more-or-less exotic, which are worthy of your attention.

Our Bromeliads — A Premier Collection

by Gary Davis

In 1974 when I first began working with the bromeliads at Denver Botanic Gardens, the collection consisted of 250 plants. The bromeliads were housed in a 200 sq. ft. greenhouse along with an orchid collection of equal size. At the time, the collection seemed quite large. I was familiar with most of the genera of the Bromeliaceae, but I really had no idea of the vast variety and beauty of this plant family. The more I work with these exotics, the more I appreciate their forms, superb colors, and their adaptability to a variety of growing conditions.

In 1977 the collection was greatly expanded. Miriam Smith of New Orleans was looking for a home for her late husband's fine bromeliad collection. Walter A. Smith was an avid collector and enthusiast of bromeliads. His collection consisted of 1200 plants, many of which were rare variegated types and unusual species and hybrids. With the help of Paul Earle, a local bromeliad hobbyist and acquaintance of Mrs. Smith, Denver Botanic Gardens received this exquisite collection.

What were we going to do with all these plants? Where would they be housed?

With the cooperation of other staff per-

sons and the not completely filled greenhouses, we were able to do some shifting of plant materials. What was once the greenhouse for growing bedding plants and other propagations became the bromeliad house. This greenhouse was approximately 750 sq. ft., and after restructuring the growing space it was finally ready to accommodate the collection, now nearly 1500 specimens. The next step was to examine each plant, divide as necessary and repot into fresh growing medium. This task, though it may not sound too difficult, was very time consuming and often painful. The plants with spines definitely took their toll on my hands and arms. It took nearly three months to sort out, divide, spray, repot or mount, and inventory all these plants. Triplicates, inferior hybrids, unnamed plants and those that were unhealthy were discarded.

Finally we finished! What we had was an all around collection—a collection that encompassed almost all genera of this fascinating plant family. This generous donation has enabled us to participate in many plant exchanges with other botanic gardens, commercial growers, and private collectors. With this further expansion of the bromeliad collection, as well as a concurrent increase in the size of the orchid collection, a major fundraising drive was started to build a new house for growing and displaying bromeliads and orchids.

Gary Davis is the senior gardener of the Horticulture Under Glass department. For 10 of his 12 years at Denver Botanic Gardens he has been in charge of the bromeliad collection.



104 *Vriesia bleheri*.

In 1981, the Margaret E. Honnen Orchid-Bromeliad Pavilion was dedicated. The Pavilion has 4700 sq. ft. of floor space and now houses both collections. The relocation of the bromeliad collection in 1981 provided the opportunity to re-evaluate it. Which plants should be kept, and how many of each? The result was a new bromeliad collection policy.

Criteria for the DBG bromeliad collection is as follows: All plants must be named. No duplicate hybrids will be kept unless of value as display plants. Of like hybrids, the inferior plants will be eliminated. Unless particularly valuable, two of each species will be retained. If rare, very showy, or good trade material, more specimens will be kept.

Even though 1200 sq. ft. of space was gained for bromeliads, the collection continued to grow and available space was again a problem. In 1983, the collection reached 3000 plants; this looked great on paper, but realistically was too large to keep in tip-top shape. Through extensive research and the subsequent elimination of many plants, the collection now stands at approximately 1800 specimens. Although not as large in total number as it once was, the number of species has risen from 650 to 1300 and of the nearly 50 genera of Bromeliaceae, Denver Botanic Gardens has 44. Our collection is the largest public collection in the nation. Plantsmen and botanical institutions from around the world contact us for exchanges and donations.

Through the mismanagement and devastation of tropical rain forests in Central and South America, many exquisite plant families including the Bromeliaceae are endangered or becoming extinct. We have in our collection many species that are rare in cultivation and that may become non-existent in the wild in only a few years or less. As time goes by, botanical institutions such as ours will be increasingly important in worldwide plant preservation. Not only is the DBG bromeliad collection of aesthetic value; it is also helping to preserve that which once was and may never be again in its native habitat.



Guzmania lingulata.

Tropical Gesneriads at Denver Botanic Gardens

by Karen Trout

The Gesneriaceae are a family of dicotyledons with worldwide geographical distribution. By far the majority of species are concentrated in tropical and subtropical regions. There are no gesneriads native to the United States, but a few genera do occur in the north and south temperate zones—notably *Haberlea* and *Ramonda*, semi-hardy rock dwellers of the Balkans.

The gesneriad family contains an estimated 2000 species in 120 genera. In addition to the 300 wild species in cultivation, many hybrids have been developed.

Karen Trout maintains the gesneriads and tropical bulbs as well as other tropical collections at Denver Botanic Gardens.

A representative selection of species and cultivars form a living taxonomic collection at Denver Botanic Gardens.

The gesneriad family is exceptionally variable in habit, form and color, yet very consistent in its botanical characteristics. The flowers have five united petals, tubular or bell-shaped in form. Most are asymmetrical or two-lipped. The sepals (calyx) are often large and leafy or brightly colored. There are two to four stamens and a one-celled superior ovary containing many seeds. Leaves are simple and commonly opposite on the stem; but they can be alternate, whorled, or in a basal rosette. Fruits can be berries or capsules.

Gesneriads exhibit a number of different growth habits. In the wild, they are either herbaceous or slightly woody perennials; a few types become small shrubs or trees. They are largely forest dwellers, growing as epiphytes on branches of trees, or in the rich organic matter of the forest floor.

At Denver Botanic Gardens gesneriads are grown in a loose, soilless mix of peat moss or Sunshine Mix that has good water retention properties, yet is not too heavy to provide adequate drainage and aeration. Fine bark, perlite and sand are added to enhance the mix's friability. Most species require even moisture and high humidity. Gesneriads should always be watered with tepid water because cold water damages the foliage. Misting is also beneficial if it is done early in the morning and only if the water is lukewarm.

Since different species are found at different elevations and habitats, the temperature requirements vary. Plants of the lowland tropics often need minimum temperatures above 60° F. Other species do well at somewhat cooler temperatures, down to about 55° F. In a greenhouse the maximum temperature should not be above 80° or 85° F.

We use a mild liquid fertilizer, Peter's 20-20-20, through the growing season, easing off a bit during our low-light winters.

Some of the most intriguing gesneriads at Denver Botanic Gardens are members of the genus *Streptocarpus*, the cape primroses. Primarily natives of eastern and southern Africa and Madagascar, most species grow in cool moist forests on shaded slopes and in rock crevices. The name *Streptocarpus* alludes to the way the mature, linear seed capsules rupture and twist into tight spirals.

Streptocarpus species exhibit a diversity of vegetative form. In most dicotyledonous plants the cotyledons or seed leaves serve only to provide nourishment for the new seedling. Once the young plant has its true leaves the cotyledons shrivel and die, but in the genus *Streptocarpus* one cotyledon continues to grow



Streptocarpus cooperi.

after germination.

In some species this single leaf is the only one the plant will ever have. The flower stalk arises from the base of the leaf which continues to elongate until the plant produces seed and dies. Such plants that fruit only once before they die are called monocarpic.

Streptocarpus cooperi C.B. Clarke is an example of the growth pattern of a unifoliate, monocarpic species. It has only one mature leaf which may measure a foot both in length and width. It produces a tall, crowded stalk of tubular, bilateral flowers, violet with white guidelines on the lower lip. A forest plant, it is found growing on steep, shady banks of earth in Natal and in mountainous parts of the Orange Free State in South Africa.

Streptocarpus primulifolius Gand., a native of the Eastern Cape Province of South Africa, is a stemless perennial with a compact rosette of leaves. Its slender, one- to two-flowered peduncles arise from each leaf axil. The tubular corolla is pale bluish-violet with five dark guidelines on the lower lip.

Streptocarpus plants are not the easiest to cultivate, with species plants usually more difficult than the hybrids. They grow best in relatively cool conditions as many species are found in mountainous regions, and thus have a sensitivity to our warm summer temperatures. They are housed in our intermediate

tropical greenhouse with a temperature range of 56° - 80° F. Soil should be a loose, aerated mixture to facilitate free drainage and cool roots. Fans providing good ventilation and free movement of air are also beneficial. *Streptocarpus* species are susceptible to thrips and mealy bugs.

Streptocarpus saxorum Engl. and *S. stomandrus* B.L. Brutt are much-branched plants with true stems and bushy habit and are placed in the sub-genus *Streptocarpella*. Their slender flowering stalks arising from leaf axils bear delicate tubular flowers with flared petal lobes in varying shades of purple. *Streptocarpus saxorum* is a rock dweller on sunny cliff faces of the Usambara and Ulugura Mountains of East Africa. *S. stomandrus* is known in the wild only from the Nguru Mountains in Tanzania.

The species of *Streptocarpella* are among the most easily cultivated tropical plants. They are resistant to disease and insect pests. They grow fast, like bright light, are extremely floriferous, and are easily propagated and attractive if kept compact.

Plants of the genus *Aeschynanthus* do well in cultivation, also. They are forest dwellers native to southeast Asia, the Himalayan region and the East Indies.

The plants are fibrous-rooted, often growing as epiphytes on logs and branches of trees. The stems, with leath-

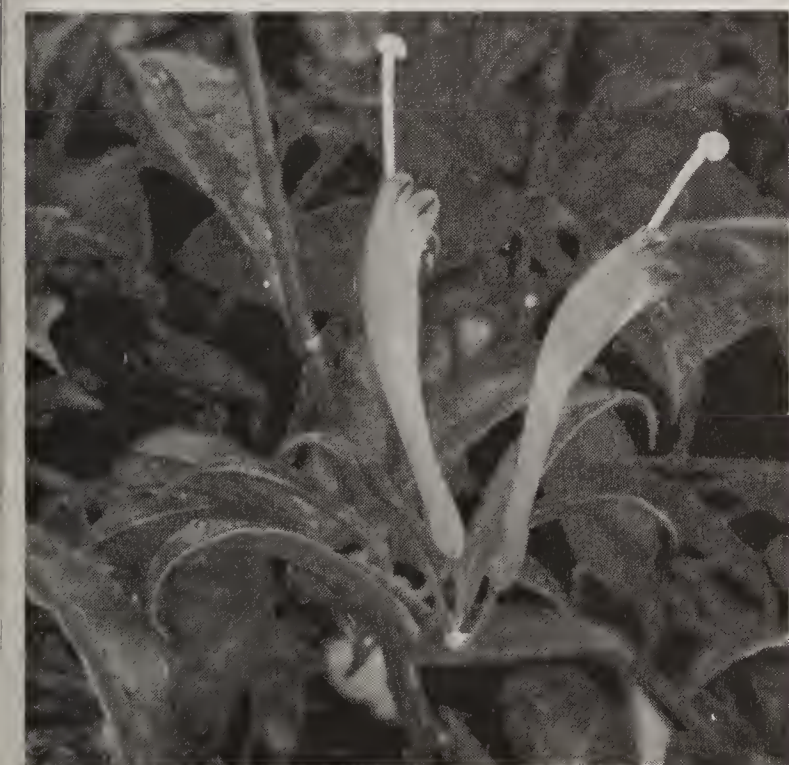
ery, opposite leaves, sprawl over rocks, climbing and rooting at the nodes. This characteristic makes them especially well suited for hanging baskets. Their tubular flowers are usually brightly colored in shades of orange and red, and their fruits are long, thin pods with many hairy seeds. Plants in the wild are thought to be pollinated by birds.

Aeschynanthus speciosus Hook. is a robust tropical straggler with terminal clusters of large, fiery yellow and orange tubular flowers in summer. It is indigenous to Borneo, Java and the Malay Peninsula.

Aeschynanthus lobbianus Hook., sometimes called the lipstick plant and native to Java, is spectacular in bloom. Its dark green, opposite leaves are tinged with purple. Terminal clusters of bright red flowers with deep purple calyxes appear in May.

Aeschynanthus species grow well in temperatures over 60° F, and are housed in our warm tropical house. They are lightly shaded from the strong sun by a thin white shade cloth.

The genus *Columnea* has been known in Europe since the 19th century, but most of the significant work in hybridization in this genus was begun by Robert E. Lee with his collection at Cornell University's Bailey Hortorium in the 1960s. They are, today, popular for greenhouse



Aeschynanthus speciosus.



Columnea 'Betty Stoehr.'

cultivation.

Columneas are widespread throughout the tropical areas of the New World—in central and northern South America and in the West Indies.

They are epiphytic trailers and thus perfect candidates for hanging baskets. A temperature range of 60° - 80° F suits them best. Bright light, but not direct sun, is needed for flower bud formation. They are especially susceptible to cold water stains on the leaves and should always be watered with tepid water.

Columnea 'Early Bird' and *C.* 'Betty Stoehr' are both excellent bloomers. They produce similar brilliant red and yellow tubular flowers with flaring petal lobes.

Plants of the genus *Nematanthus* somewhat resemble *Aeschynanthus* species. They have leathery, opposite leaves and trailing stems and are found growing as epiphytes in humid forests. There are some subshrubs in this genus which develop woody stems with age. *Nematanthus* is known for its pouch-shaped flowers. All are native to Brazil.

Nematanthus wettsteinii (Fritsch) H.E. Moore, candy corn plant, is an attractive and easily grown plant with shiny green, opposite leaves and bright orange and yellow, pouch-shaped flowers. In time its branches become woody taking on a shrubby appearance. It does well in hanging baskets. Like many gesneriads, its foliage is sensitive to cold water which will spot and damage the leaves.

An attractive hybrid, *Nematanthus* 'Tropicana' has deep green leaves with a tinge of purple on the stems. The showy flowers are, again, pouch-shaped, the petals striped with maroon and yellow, and the calyx, large, leafy and orange.

Nematanthus species respond to bright light, but not direct sun, and they can dry out slightly between waterings. Here, they are grown in a tropical greenhouse with a temperature range of 60° - 80° F.

Achimenes is a genus of deciduous perennials with scaly rhizomes, an adaptation that enables the plants to survive through seasons of drought in a dormant underground condition. They grow in moist, humus-filled, wooded ravines and

slopes. There are about 50 species native to Guatemala, Mexico, and Brazil and a large number of hybrids as well. The flowers are narrowly tubular with five flaring, rounded lobes—similar to some *Streptocarpus* species. *Achimenes* are popularly grown in hanging baskets. They are summer bloomers that remain dormant throughout our winters, stored in pots on the greenhouse shelf.

Achimenes erecta (Lam.) H.P. Fuchs has bright red flowers and green, ovate, toothed leaves. It is the type species for the genus introduced in England in 1778.

Like *Achimenes*, *Kohleria* species grow from scaly rhizomes which serve as underground storage organs that see the plants through the dry season. Each scale is actually a modified leaf which can be propagated to form a new plant.

Kohlerias are herbaceous perennials and subshrubs with an upright growth habit. Their leaves are very hairy (almost fuzzy), large, and in whorls of three or four. Flowers are tubular, bilateral, and somewhat pendant.

There are several *Kohleria* species and hybrids in our collection. One of the showiest is *Kohleria eriantha* (Benth.) Hanst., a tall robust plant with green, fuzzy leaves rimmed with red. The large hairy flowers are red-orange with yellow spots inside the petal lobes. It is from the highlands of Colombia.

Kohlerias need a semi-dormant period of 50° - 60° F in winter, when water is greatly reduced and no fertilizer is given. During the growing season they must be kept in bright indirect light (direct light may burn the leaves), fertilized to facilitate the formation of flower buds, and kept pinched back to encourage a bushy plant.

Episcia species are a group of gesneriads often grown specifically for their colorful foliage. Different species and cultivars exhibit a great variety of patterns, shades and textures of leaves. They are terrestrial herbs characterized by a stoloniferous habit, forming large colonies in shaded forests. All 35 species are endemic to southern Mexico and Brazil.

Another gesneriad genus from Central



Columnea for hanging baskets.

and South America is *Codonanthe*. These plants are primarily epiphytic woody vines found in low altitude forests.

In the wild, these plants are found growing on ant hills of compacted granules of soil forming a loose airy substrate. The ants harvest nectar from the nectaries on the lower leaf surfaces and at the sepal bases of the plant, and may also perform the function of cross-pollination.

These plants grow well in cultivation at temperatures above 60° F and high humidity. Cold water is very injurious to foliage. Our three species have very similar white, tubular flowers with flaring lobes. Inside the throat are yellow and maroon dots. Their leaves are rounded to elliptic depending on the species; all are fleshy. Their trailing character makes them good candidates for hanging baskets.

Every year, usually in July or August,

there is an educational exhibit of the gesneriad family at Denver Botanic Gardens. The Gesneriaceae is a significant collection at the Gardens in that it is a good representation of a large tropical plant family. The collection is used primarily for educational purposes and decorative displays.

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Malaysian Rhododendrons

by Ron McLellan

One of the newest groups of woody ornamentals to be planted in the Boettcher Memorial Conservatory are the Malaysian rhododendrons. The term Malaysian rhododendron actually represents species that are native to the Malayan Peninsula, New Guinea, Borneo, Philippine Islands and northern Australia.

Most people are familiar with the genus *Rhododendron* as the Asiatic and North American species or their hybrids. The large number of species, the years under cultivation and their introduction into temperate regions probably account for their popularity.

Although the Malaysian rhododendrons make up approximately a third of the genus, they are not as well-known because the majority of their species were not known until after World War II.

The first to be discovered was *Rhododendron malayanum* Jack in 1823 by an English horticulturist, Dr. William Jack. By the early 1890s more than 200 hybrids had been developed by the Veitch Nursery in England from a small number of species collected by their plant hunter, Thomas Lobb. Since they are not hardy in temperate zones, most of these hybrids were lost during World War I when it became too expensive to operate the conservatories and greenhouses necessary

for their survival. Further study and collection of Malaysian rhododendrons was delayed again because of the occupation of the regions of their nativity during World War II.

In the 1960s interest began to grow with the introduction of new species, in part, because of the work done by Hermann Sleumer, German taxonomist, who had studied these rhododendrons for many years. Renewed interest among horticulturists was sparked by the wide color spectrum varying from whites, pinks, reds, oranges, to golden yellows, as well as the large size of the flowers, up to 4 inches in some species.

The Malaysian rhododendrons, both evergreen and deciduous, can range in size from dwarf shrubs to small trees. Most species grow in moss forests either as shrubs or as epiphytes. Those species that grow mainly as terrestrials inhabit the higher forests and savannas. Species that grow in lowland forests are epiphytic. Above timberline they become dwarf.

The vast majority of Malaysian rhododendrons are grouped into the section *Vireya* on the basis of scales or epidermal trichomes on the underside of leaves, ends of branches or the flower region. Those without scales belong to four other minor sections that contain only 12 out of the approximately 288 known species. Scale shapes and color are also used, in part, to divide the section *Vireya* into subsections.

Ron McLellan maintains the collections in Boettcher Memorial Conservatory at Denver Botanic Gardens.



Rhododendron christiana x *R. jasminiflorum*.



Rhododendron aurigeranum x *R. laetum*.

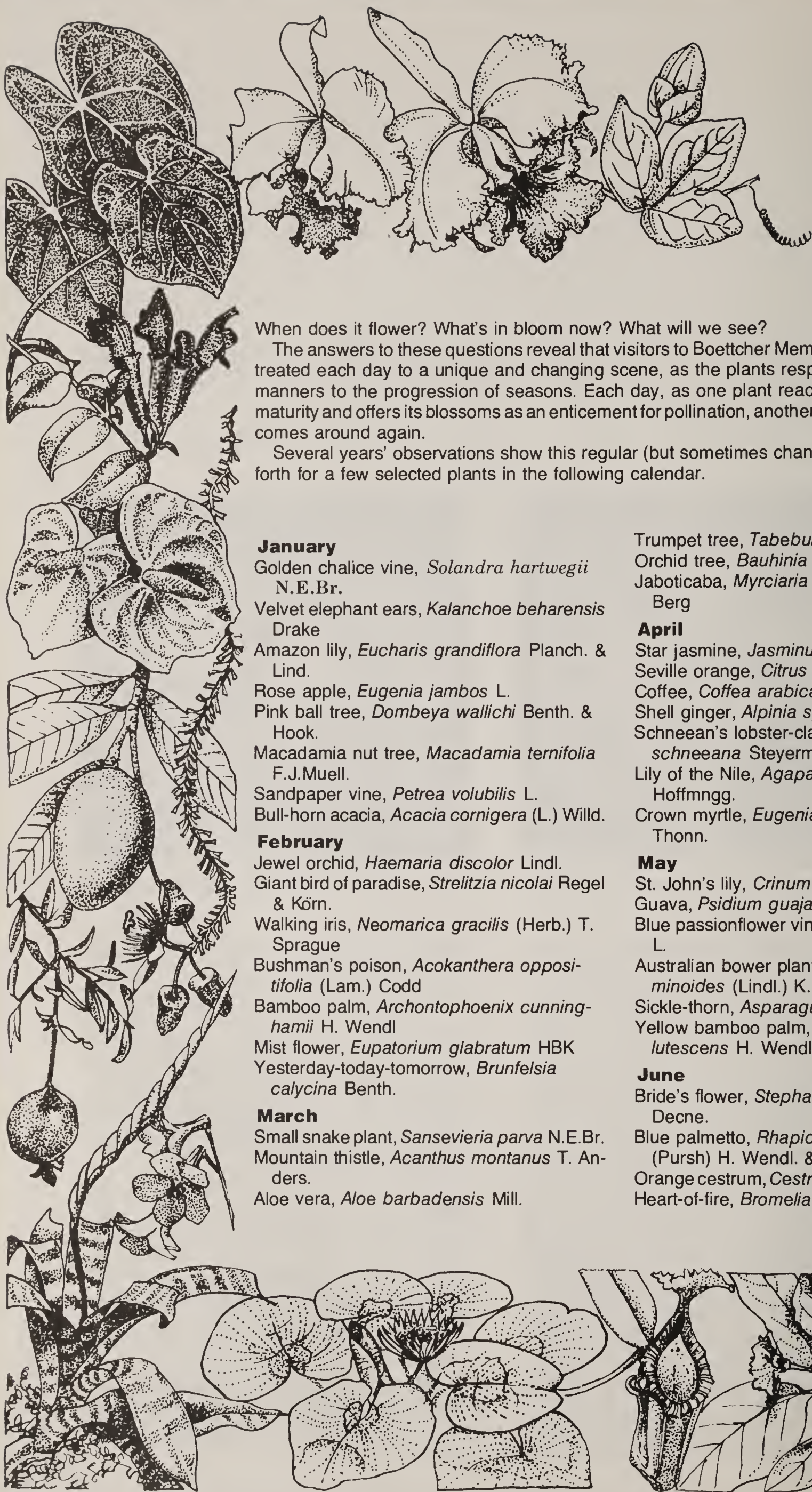
The cultural requirements for vireya rhododendrons are few. They inhabit a region near the equator where there is little seasonal change. However, they are suited to a wide fluctuation (up to 30° F) in temperature between night and day. Vireyas need a humid environment, and as summer temperatures increase, so should the humidity. The light conditions needed are full sun until mid-morning and filtered sun or shade for the rest of the day. They should be grown in a highly aerated, soilless mixture. Most growers recommend equal parts of small bark, coarse perlite and coarse peat moss. They should be watered thoroughly, then the growing medium allowed to dry out a little before watering again. They do best if kept on the dry side except when flowering. Half-strength, water-soluble fer-

tilizer or fish emulsion should be added during spring and summer.

For those who have a greenhouse or heated atrium and would like to grow a *Vireya*, there is a large selection available from mail order nurseries. The Helen Fowler Library at Denver Botanic Gardens has a good collection of their catalogs for reference.

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When does it flower? What's in bloom now? What will we see?

The answers to these questions reveal that visitors to Boettcher Memorial Conservatory are treated each day to a unique and changing scene, as the plants respond in their individual manners to the progression of seasons. Each day, as one plant reaches its procreative maturity and offers its blossoms as an enticement for pollination, another retires until its season comes around again.

Several years' observations show this regular (but sometimes changeable) pattern of flowering set forth for a few selected plants in the following calendar.

January

- Golden chalice vine, *Solandra hartwegii* N.E.Br.
- Velvet elephant ears, *Kalanchoe beharensis* Drake
- Amazon lily, *Eucharis grandiflora* Planch. & Lind.
- Rose apple, *Eugenia jambos* L.
- Pink ball tree, *Dombeya wallichii* Benth. & Hook.
- Macadamia nut tree, *Macadamia ternifolia* F.J.Muell.
- Sandpaper vine, *Petrea volubilis* L.
- Bull-horn acacia, *Acacia cornigera* (L.) Willd.

February

- Jewel orchid, *Haemaria discolor* Lindl.
- Giant bird of paradise, *Strelitzia nicolai* Regel & Körn.
- Walking iris, *Neomarica gracilis* (Herb.) T. Sprague
- Bushman's poison, *Acokanthera oppositifolia* (Lam.) Codd
- Bamboo palm, *Archontophoenix cunninghamii* H. Wendl
- Mist flower, *Eupatorium glabratum* HBK
- Yesterday-today-tomorrow, *Brunfelsia calycina* Benth.

March

- Small snake plant, *Sansevieria parva* N.E.Br.
- Mountain thistle, *Acanthus montanus* T. Anders.
- Aloe vera, *Aloe barbadensis* Mill.

- Trumpet tree, *Tabebuia pentaphylla* H.
- Orchid tree, *Bauhinia blakeana* S.T.D.
- Jaboticaba, *Myrciaria cauliflora* (DC.) Berg

April

- Star jasmine, *Jasminum dichotomum*
- Seville orange, *Citrus aurantium* L.
- Coffee, *Coffea arabica* L.
- Shell ginger, *Alpinia speciosa* D.Dietr.
- Schneean's lobster-claw, *Heliconia schneeani* Steyerf.
- Lily of the Nile, *Agapanthus africanus* Hoffmngg.
- Crown myrtle, *Eugenia coronata* Schumacher & Thonn.

May

- St. John's lily, *Crinum asiaticum* L.
- Guava, *Psidium guajava* L.
- Blue passionflower vine, *Passiflora caerulea* L.
- Australian bower plant, *Pandorea jasminoides* (Lindl.) K. Schum.
- Sickle-thorn, *Asparagus falcatus* L.
- Yellow bamboo palm, *Chrysalidocarpus lutescens* H. Wendl.

June

- Bride's flower, *Stephanotis grandiflora* Decne.
- Blue palmetto, *Rapidophyllum hystrix* (Pursh) H. Wendl. & Drude
- Orange cestrum, *Cestrum aurantiacum* L.
- Heart-of-fire, *Bromelia balansae* Mez.

al ar

ossoms ear

ing bottlebrush tree, *Callistemon vim-*
lis (Soland.) Cheel.
an hedge cactus, *Cereus peruvianus*
Mill.
f-the-valley orchid, *Osmoglossum pul-*
ellum Batem.

in tulip tree, *Spathodea campanulata*
auvois.

oon creeper, *Quisqualis indica* L.
ca plant, *Manihot esculenta* Crantz
a, *Dahlia pinnata* Cav.

palm, *Rhapis excelsa* (Thunb.) A.
nry

lian plume, *Jacobinia carnea* Nichols.
ng wedelia, *Wedelia trilobata* (L.)
S.Hitchc.

ust

apple guava, *Feijoa sellowiana* O. Berg
ing bromeliad, *Neoregelia carolinae*
er) L.B.Sm.

9-leaf crassula, *Crassula falcata* Wendl.
leadwort, *Plumbago capensis* Thunb.
cactus, *Pereskia sacharosa* Griseb.

tember

urgh's fig, *Ficus roxburghii* Wall.
grass, *Setaria palmifolia* (Koen.) Stapf.
f cavendish banana, *Musa accuminata*
lla cv. Dwarf Cavendish
granadilla, *Passiflora quadrangularis*

any time of the year visitors to our conservatory will also be treated to dozens of blooming
s which flower the year around, oblivious to the seasons passing by beyond their tropical
asure, and to still dozens more whose cyclic floral display is in response to factors
ated to the sun's waxing and waning.
hen does it flower? The answer lies deep within each plant, awaiting your discovery the
time you visit.

adar prepared by Larry Lotta, Horticulture Under Glass, and artist Carolyn Crawford.

October

Papaya, *Carica papaya* L.
Arabian jasmine, *Jasminum sambac* (L.) Ait.
Butterfly ginger, *Hedychium coronarium*
Koen.
Traveler's tree, *Ravenala madagascariensis*
J.F.Gmel.
Spit plant, *Crossandra infundibuliformis* (L.)
Nees.
Yellow jacobinia, *Jacobinia chrysostephana*
Benth. & Hook.
Vanilla, *Vanilla pompona* Schiede

November

Giant carrion-flower, *Stapelia gigantea*
N.E.Br.
Shrub aloe, *Aloe arborescens* Mill.
Collin's heliconia, *Heliconia collinsiana*
Griggs.
Baby Joshua tree, *Sedum multiceps* Coss. &
Durieu.

December

Redheaded powder puff tree, *Calliandra*
haematocephala Hassk.
Blue clock vine, *Thunbergia grandiflora*
Roxb.
Elegant pink-ball tree, *Dombeya elegans*
Cordem.
Chinese loquat, *Eriobotrya japonica* Lindl.
Blue tillandsia, *Tillandsia cyanea* E. Morr.
Pink banana, *Musa rosacea* Jacq.



The Alpine House: A Special Kind of Greenhouse

by Panayoti Kelaidis

The very notion of an alpine greenhouse strikes many people as contradictory: aren't greenhouses intended for growing tropical plants? Yet over the last century, quite a number of greenhouses have been specifically constructed in order to grow alpiners. In England there are several companies that do nothing but construct alpine houses.

The traditional alpine house is little more than an unheated greenhouse. In the many European botanic gardens that have such features, the purpose of alpine houses is to display alpine plants in their collections so that people can view them up close. Most hobbyists who have such structures use them for other reasons as well: a corner is usually relegated to propagation. Plants which will not grow out-of-doors in cool, maritime climates will often survive with the protection provided in an alpine house. So these houses often become collections of plants from steppe climates, wet-sensitive alpiners and Mediterranean plants which have an alpine look about them.

Thus in Europe, the primary purpose of alpine houses is to grow plants from colder but drier climates. There is no concern about low temperatures in alpine houses, since their denizens can withstand the cold of the European climate as long as they remain dry. It is not unusual to find

a variety of western American alpine plants growing in European alpine houses: *Lewisia*s are favorites—especially the bitterroot, *Lewisia rediviva* Pursh, the state flower of Montana. This plant grows in areas where temperatures regularly drop to minus 40° F, yet invariably dies when grown out of doors in maritime climates. It is very sensitive to wetness in the winter. Grown in an alpine house, however, where watering can be controlled, the bitterroot once again becomes perennial.

Other plants frequently encountered in European alpine houses include the many high alpiners that have woolly or hairy leaves: these are accustomed to passing the winter under a deep layer of snow where they are freeze-dried (so to speak) and where there is no possibility of rotting. In northeastern United States, however, winter is a complicated affair, by comparison. "Thaws" can occur in almost any month, and rain often falls between snowstorms: plants emerge from the eastern winter sodden, and hairy-leaved alpiners are often casualties. The rainy English winter is more devastating on such plants as the alpine forget-me-not, the dozens of choice, woolly-leaved drabas and especially dionysias—a group of cushion primrose relatives from the Near East which are currently cultivated plants throughout Europe. These are all impossible to grow out of doors in climates with rainy winters.



Erodium chamaedryoides—Corsican storkbill from the Mediterranean region.

When the Alpine House was first planned at Denver Botanic Gardens, it was conceived as a place where plants could be displayed much as they are at European botanic gardens. The alpine house was designed to take advantage of winter sun, and yet to be fairly efficient in cooling during the summer season. It has proven to be quite versatile and reliable over its first three years in operation. This period coincided with the planting of the Rock Alpine Garden, and the Alpine House assumed a secondary and supporting role to that project. It was used to protect cuttings and individuals of plants that were marginally hardy in our sunny winters with fluctuating temperatures until the proper microclimate could be found for them out of doors. It served as a halfway house for plants in the spring and fall on their way to the garden.

As the Rock Alpine Garden has matured, it is becoming increasingly apparent that Colorado is an excellent climate to grow a broad range of alpine plants. Many of the wooly alpine plants such as the alpine forget-me-not, *Eritrichium nanum* (L.) Schrad., considered impossible to grow, have proven amenable out of doors here. Even the wooly drabas are easy to grow. *Lewisia rediviva* survives in a variety of sites, and a few species of *Dionysia* have adapted to our outdoor conditions.

Most of the alpine plants cosseted in English

alpine houses grow readily out of doors here. Harder for us to grow are those alpine plants that emanate from maritime climates. While a few New Zealand alpine plants have adapted to our climate, most plants from that island require acid soils, cool, moist air and less insolation than they naturally receive here. These have proven growable in the Alpine House.

Many of the ericaceous alpine plants of the Himalayas also react unfavorably to the wind, dry air and winter sun of our climate. The Alpine House provides a refuge for these as well. Perhaps the greatest use for such a house, however, is for those temperate plants that need cooler conditions than can be provided in conventional greenhouses, but will not survive out of doors in Colorado. These include literally hundreds of cushion and rock plants from Mediterranean climates in Europe, California or South Africa.

The Corsican storkbill, *Erodium chamaedryoides* (Cav.) L'Her., which grows quite widely throughout the western Mediterranean region is such a plant. Other Corsican plants have proven quite hardy here, but the forms of this plant most commonly cultivated will not tolerate subzero temperatures. In the Alpine House, however, it is rarely without a bloom. It occurs in a robust, white-flowered form, a deep pink miniature as well as a tiny double-flowered mutant.



Leucojum autumnale, Snowflake, is an autumn blooming bulb from the Mediterranean region.

We continue to make cuttings of these, and experiment with them in special microclimates out of doors. Meanwhile, the mother plants grow even larger and more impressive in the Alpine House.

Now that our energies are not channeled primarily into filling an expansive garden, the Alpine House is assuming a new place of importance. In addition to housing plants that do not survive out of doors, it is a fine place to show off tiny plants which become lost in the boulders of the Rock Alpine Garden. Each spring a variety of tiny bulbs are brought into the Alpine House from cold frames. As sand in the Alpine House is replaced by turf (a clay product fired at high temperatures that resembles rock chips), the displays are becoming far more naturalistic and alpine-looking.

For the last three years, a significant focus of attention has been the displays mounted in the back of the house by

Evelyn Murrow, a volunteer at Denver Botanic Gardens. She has presented fourteen professional quality displays that illuminate many aspects of alpine plants both in nature and in the garden. They include both living plants, as in her displays on the family Crassulaceae, and dried plants as in her displays on the genus *Zauschneria* or on alpine plants of Quandary Peak in the Mosquito Mountains of central Colorado.

Presently, our energies are focused on preparing the entire Rock Alpine Garden and Alpine House for the Second Interim International Rock Garden Plant Conference that will be held in Colorado from June 28 to July 3, 1986. This is only the second international conference on rock gardening to take place out of Europe. The theme of the conference is Rocky Mountain Plants, and these will be featured both in the garden and in the Alpine House.



Viruses — A Serious Problem for Orchid Growers

by Peggy Brown

Virus diseases are a serious problem in orchids grown in horticultural settings. Orchids collected in the wild have proven to be virus-free. It is only when they are brought into artificial environments—our homes and greenhouses—that they become infected. The infecting agent is not known to be transmitted through the seed, so seedlings are generally free of viral disease. However, about 25 to 30 percent of mature flowering plants in cultivation, including many genera, have been shown to be infected by *Cymbidium* mosaic virus (CyMV) or *Odontoglossum* ringspot virus (ORSV).

Some of the symptoms of viral infection are color break (mottling and streaking of color) and deformation of flowers and streaking and spotting of leaves. However, the plant can be heavily infected, yet show no symptoms, but still be able to transmit the virus to another plant.

Since these symptoms can also be caused by other factors such as bacterial or fungal infection, a means of detecting a specific virus must be used. At Denver Botanic Gardens a serological method is employed to test for *Cymbidium* mosaic virus and *Odontoglossum* ringspot virus.

In order to understand how serological virus testing works, we must first understand how viruses operate and how higher organisms combat them.

A parasite is an organism that lives on and causes damage to another organism. Although most orchids grow on trees and other plants, they receive no nourishment from them, and are, therefore, not parasitic as is sometimes believed. The host plant merely provides support for the orchid. In contrast, viruses are one of the truest forms of parasite. Unable to reproduce or divide on their own, they must take over a host cell in order to multiply.

Each strain of virus has a specific site that attaches to a specific site on a particular host cell. When the virus finds its particular cell, it attaches to its site and injects its own genetic data into the host. The host genetic material is made inoperable and the cell is forced to make more viruses. When the viruses are complete, the host cell erupts and the new viruses are released to find more cells. The time it takes to make the new viruses accounts for the incubation period in viral diseases.

If an organism is fortunate enough to have an immune system (plants do not), it can fight a virus attack. When a foreign particle such as a virus enters the system it is ingested by a macrophage which identifies it and produces an antigen which makes T cells multiply and, in

Peggy Brown maintains the orchid collection including both the display area and the greenhouse and is carrying out the viral testing program of the orchids at Denver Botanic Gardens.



Petri dish prepared for determining the presence of orchid virus.

turn, stimulate and help B cells multiply and produce antibodies. The antibodies seek out the virus and attach themselves to the site on the virus where it would normally attach itself to the host cell thus neutralizing but not destroying it.

This is the premise upon which our virus testing is based. Animals, such as rabbits and goats, are injected with the virus, and their immune system manufactures antibodies. Their blood containing the antibodies is collected and made into a serum and frozen for future use in testing.

Agar, containing sodium dodecyl sulfate and sodium chloride, is prepared, the pH adjusted to 8.0, and poured into petri dishes. When the agar has solidified, three sets of holes are punched into it, each set consisting of a central well surrounded by six peripheral wells.

Plant pieces are collected, using a sterile razor blade for each plant. Plant name and accession number are carefully recorded on a log sheet along with a description of the condition of the plant. Two discs are punched from each plant piece with a paper punch that has been dipped in alcohol and flamed. Pieces for the ORSV test are placed in a microtiter tray and suspended over boiling water for five minutes to increase their sensitivity.

This is not needed for the CyMV test.

The plant pieces are placed in the peripheral wells of the agar with the serum in the middle one. A known infected disc and a known disease-free disc are always included in each group as a control. Tweezers used to handle the discs are dipped in alcohol and flamed between each plant.

The petri dishes are put into an airtight container and kept at room temperature for 24 to 48 hours. Material from the plant's vascular system and the serum containing the antibodies diffuse toward each other. If the plant has the virus infection, it is attacked by the antibodies in the serum and a latticework that can be seen with the naked eye forms between the plant well and the serum well. If the plant is virus-free, this pattern does not develop.

Since there is no known cure for these viral diseases in orchids, infected plants should be destroyed or isolated. Because a virus must enter the plant through the vascular system, it is usually transmitted from plant to plant by unsanitary cultural techniques when repotting or cutting flowers. Equipment and tools such as pots and knives must be sterilized before coming in contact with a plant, and all potting medium must be discarded after use. A virus can remain inactive on a knife for a long time and become active



Peggy Brown collecting plant pieces for virus testing.

again when introduced to a plant.

One of the main functions of the orchid collection at Denver Botanic Gardens is in educational and aesthetic displays for the public. This means the plants have to be replaced as the flowers fade, which often results in broken roots and damaged leaves. If a healthy plant replaces a plant with a virus, there is a chance that it could pick up the infection from the display area.

The only way to prevent this transfer is to destroy all infected plants, and test all incoming plants before adding them to our collection. Such a policy, if followed consistently, will not only add to the beauty of our display but will signifi-

cantly increase the monetary value of our collection.

This could be the first step in an extensive hybridizing program in which virus-free plants could be offered with confidence.

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Tropical Bulbs

by Karen Trout

The tropical bulbs at Denver Botanic Gardens are a collection of loosely allied plants, all monocotyledonous and possessing some type of underground food and water storage organ. They are, for the most part, native to tropical and subtropical areas.

The term "bulb" is used here in a general and inexact sense and may include true bulbs, corms, tuberous roots, and rhizomes. All of these serve essentially the same function. They enable the plants to survive periods of drought in a subterranean, dormant state until seasonal conditions are again suitable for growth.

Our tropical bulb collection is not a specific taxonomic group of plants such as the orchid or bromeliad plant families. There are, however, several distinctive families in which the majority of the "bulbous" plants are found. These are the monocotyledonous lily, amaryllis, and iris families. Other plant families contain scattered species that have similar structural and cultural habits, but by far the highest percentage of bulbs are in these three families.

Throughout the world the main areas of distribution of bulbous plants indicate that the majority occur in regions which undergo a period of drought or marked

seasonal change. Though some truly tropical species are evergreen and retain their leaves year around, most have deciduous foliage which dies down at the end of each growing season. The previous season's vegetative growth manufactures food materials that are stored in the underground parts of the plant.

These stored nutrients initiate the formation of buds for the next growth period, and the immediate availability of food enables the rapid development of flowers and seeds before the dry cycle sets in again. Often these plants flower early in the spring, and in some species before the leaves appear.

When growing tropical bulbs in the greenhouse or in our homes, the most important considerations are dormancy periods and corresponding temperature regimes, light and fertilizer. Some plants go into complete dormancy and should be kept entirely dry. Others have only a semi-dormant rest period and retain their leaves throughout it. Water should be reduced at this time and fertilizer should be withheld.

When bulbs are in active growth they should be fertilized regularly. In pot culture they require a well drained, loose soil mix. The majority prefer to be root bound, with more prolific flowering when they have not been disturbed by repotting for several years.

At Denver Botanic Gardens the tropical bulbs are kept in a greenhouse where

Karen Trout maintains the gesneriads and tropical bulbs as well as other tropical collections at Denver Botanic Gardens.

the winter temperature range is 56° - 80° F. During dormancy periods some of the semi-hardy bulbs are moved into a cool fiberglass house with a winter temperature range of 40° - 50° F. The house is only lightly shaded with thin white shade cloth. A few bulbs—those from tropical forested areas—require a more shady situation. Our sunlight is sufficient for bulb species originating in the northern hemisphere, but bulbs from the Mediterranean type climates of central Chile and South Africa, such as freesias and lachenalias, need as much light as possible during their growing seasons which are our autumns and winters.

By considering the type of climate and natural habitat of each plant species in our collection, we are better able to understand and apply correct cultivation requirements.

There are several notable areas of the world where bulbous plants have originated and where they are especially abundant. The Mediterranean or subtropical, dry-summer climate is one of the most important bulb producing weather regimes. It is characterized by a cool, wet winter and a hot, dry summer with autumn, winter and spring being the seasons of active growth. Five regions worldwide where the Mediterranean type climate occurs are: the lands that border the Mediterranean Sea, coastal California, central Chile, the Cape region of South Africa, and parts of western and southern Australia.

The Cape Province of South Africa with its varied climatic regimes has a high percentage of bulbous flora and is one of the richest regions on earth in flowering plants. In the southwestern part of the Province there are winter rains and long, hot, dry summers. The best month for spring flowering is September; but one will find plants in bloom all through the winter and into late spring, from July to October. During summer, from December to March, most bulbs experience a period of dormancy; annuals have completed their life cycles and gone to seed, and trees, shrubs and perennials have developed various ways of adapting to sea-

sonal drought. The Cape peninsula has a great diversity of bulbous genera, including species of *Lachenalia*, *Nerine*, *Gladiolus*, *Moraea*, and *Watsonia*.

The remainder of South Africa possesses another distinctive bulb producing climate, that of the veldt or savannah type country. This regime with a cool, dry winter and a hot, wet summer is also found in some parts of North and South America. However, some areas along the southeast coast of Africa have greater precipitation that is more evenly distributed through the year. The high mountains and tablelands of eastern South Africa experience colder, more severe winters.

The genus *Watsonia* of the iris family is endemic to South Africa. Closely related to *Gladiolus*, the plants possess fibrous-coated corms and flat, sword-like leaves arranged fanwise. The flowers, borne in several tall spikes, are tubular and somewhat curved with six perianth segments flaring at the ends.

The bugle lily, *Watsonia galpinii* L. Bolus, found in the wild in moist places or near water on the Cape, has scarlet-orange flowers appearing in late summer. As a greenhouse plant, it requires a cooler than normal temperature—45° - 60° F—and full sun.

The *Watsonia* species native to the eastern Cape Province bloom during spring and summer while the southwestern Cape species are winter growers.

Several South African *Moraea* species grown from seed are now thriving at Denver Botanic Gardens. *Moraeas* or peacock flowers, with fibrous rooted corms, resemble plants of the genus *Iris* of the northern hemisphere. However, *moraeas* have separate perianth segments while iris's six segments are joined into a tube at their bases. *Moraea* flowers have three inner, reduced true petals, three outer reflexed sepals and three petal-like styles. They are usually bicolored in variable shades of blue, yellow, orange, brown and white. Species distribution ranges from tropical Africa to the eastern Cape where they grow and flower in summer and to the southwestern Cape



Cyrtanthus staadensis—a fire lily.

where they grow in winter and flower in early spring.

Cyrtanthus, the fire lilies of the amaryllis family, bloom most abundantly after veldt fires. Of the nearly 50 species, most are endemic to South Africa. The plants form large, tunicated bulbs from which arise narrow, strap-shaped leaves. Flowers are funnel-shaped with long, curved perianth tubes, and are borne in umbels on leafless scapes.

Cyrtanthus obliquus Ait. is a tall plant with bright red, drooping flowers tinged with yellow at the base. Its leaves are produced after flowering in May and June. The first species of the genus to be described, it was collected in 1774 in the Cape Province.

Along the borders of Natal and Lesotho in southern Africa, the Drakensberg Mountains are the home of *Rhodohypoxis baurii* (Bak.) Nel. This dwarf bulb grows at high altitudes on wet rock and in small bogs. It has a corm-like root stalk with linear, hairy leaves. The flowers are rotate and vary in color from white to deep red according to the plant's locality.

In active growth *Rhodohypoxis* needs full sun, copious watering, and extremely well-drained soil. It spends its winters at Denver Botanic Gardens in our cool fiberglass house, where the temperature range is 40° - 50° F. It needs to be kept very dry during winter.

The moraeas of the Drakensberg also grow in moist areas. These high mountains receive snow in winter but the majority of precipitation falls in summer.

Central Chile boasts a Mediterranean type climate which features an area of





Hippeastrum species from Chile.

winter rainfall between the Andes Mountains and the Pacific Ocean. Many bulbous genera have been found here. Among them are some species of *Hippeastrum* of the amaryllis family. A large genus of about 65 species, it is native from Mexico and the West Indies south to Argentina. *Hippeastrum* flowers are often very showy. Leaves are all basal, long and strap-shaped. The genus has been used in hybridization since the late 17th century. These hybrids are known today by the common name amaryllis.

Hippeastrum reginae (L.) Herb., a species *hippeastrum* in the Denver Botanic Gardens collection, was introduced into cultivation in Europe and was a parent of the first amaryllis hybrid in 1799. It has 2-foot-long strap-shaped leaves and tapering trumpet-shaped flowers that can be 4 inches across, brilliant red with a white star in the throat.

Hippeastrum advenum (Ker-Gawl.) Herb. is a native of Chile. Its scarlet flow-



Alstromeria species—a florist's favorite.

ers have a yellow median line through rather narrow perianth segments. Linear, blue-green leaves appear after the flowering period in late summer.

During *hippeastrums*' dormant period they should be kept dry. Ours remain on the greenhouse shelves during their rest period at a winter night temperature of 56° F.

Many *Alstromeria* species occur in the Chilean Andes. Their multicolored, funnel-shaped flowers are composed of six perianth segments. These tuberous



Zephyranthes species—a rain lily.

plants are used extensively in the floral trade today.

In northern Mexico summer rainfall from late May to September or October and light rain in winter progresses into a longer, wetter warm season and a shorter, drier winter southward toward the equator.

Species of *Zephyranthes* of the amaryllis family are commonly known as zephyr lilies, flowers-of-the-west-wind, or rain lilies. Closely related to *Habranthus* and *Hippeastrum*, they are natives of the Americas from the warm temperate region into the tropics. These beautiful, symmetrical, funnel-shaped flowers with flaring petals are among the favorites of our collection. *Zephyranthes grandiflora* (Lindl.), native to Mexico and Guatemala, has linear leaves and clear pink blossoms on single scapes that bloom in profusion. Its deciduous leaves will yellow and die down naturally. It can be given a rest period in a dry pot of soil at a winter night temperature of 45° F. The bulbs can be brought out of dormancy merely by a thorough soaking. This species will bloom both when there are no leaves present and when the bulbs are in leaf.

Sprekelia formosissima (L.) Herb., also of the amaryllis family and indigenous to Mexico and Guatemala, is a summer grower at Denver Botanic Gardens. Commonly called the Aztec lily, it has symmetrical, bilateral, deep-crimson flowers and linear leaves tinged with maroon. A primary requirement for cultivation is a well-drained soil. It is deciduous and is kept leafless and completely dry on the greenhouse shelf during winter.

In the mountainous parts of tropical South America many new bulbous species and even new genera are being discovered and described each year, especially in the amaryllis and iris families. East of the Andes and south of the equator a general climate with cool dry winters and wet summers prevails. In our collection are species of several genera from this region, notably *Hippeastrum*, *Stenomesson*, and *Habranthus*.

Habranthus and *Zephyranthes* have flowering regimes that largely depend on

the last good rain, hence the common name, rain lilies. *Habranthus robustus* Herb. produces solitary, white flowers slightly tinged with pink. They are funnel-shaped, somewhat irregular, and about 3 inches across. The species is native to Uruguay and Argentina.

In tropical Africa rainfall is seasonal, often with two rainy seasons interspersed with dry periods. It is wetter near the equator, and the dry season is very short. Farther south the dry periods are longer, and savannah type vegetation characterized by low, dryland trees and grasses becomes dominant.

The genus *Gloriosa*, or climbing lilies, are deciduous, twining vines that arise from distinctive U- or Y-shaped tubers. They grow wild in warm, scrubby grasslands and climb with the help of their tendril-tipped leaves. Their flowers are pendant, with reflexed perianth parts, usually six in number with crisped edges.

Gloriosa superba L. of tropical Africa and Asia has yellow to orange flowers and blooms in late summer or fall. *Gloriosa rothschildiana* O'Brien is native to tropical east Africa and produces fiery red and yellow flowers.

It is beneficial to support gloriosas' herbaceous trailing stems on trellis work or wire. They need light shade in cultivation. These lilies spend their winters at Denver Botanic Gardens leafless and dormant in dry pots on the greenhouse shelves.

Crinum is the most common bulbous genus found growing throughout tropical Africa. These plants are also native to South America, India, southeast Asia and Australia. Most of the species in our collection are indigenous to tropical Asia, known for its heavy deluge of monsoon rains during the summer season and the rather dry period preceding it. Many *crinum* species are found growing in moist, swampy areas, near streams or along the seashore.

The large bulbs give rise to long fleshy leaves. The inflorescence originates from the side of the bulb, not through its center. Flowers are funnel-shaped with six equal segments united at the base, some-



Crinum asiaticum —St. John's lily.

times narrow and often spreading. Crinums are most distinctive in the Gardens' collection.

Crinum asiaticum L. var. *variegatum*, sometimes called poison bulb, from tropical Asia, is a robust plant with a single large tunicated bulb. The long tapering, somewhat fleshy leaves are strikingly variegated with white lengthwise. The many-flowered umbels of white, spidery flowers sometimes begin to bloom before the flowering scape has elongated past the rosette of leaves.

The milk and wine lily, *Crinum zeylanicum* L. has beautiful trumpet-shaped white blossoms with purplish keels. They are fragrant and open in the evening, wilting after one night. They arise in umbels atop tall, maroon-tinged stalks from a large, cylindrical bulb with wavy

leaves. This crinum is also an inhabitant of the warm parts of Asia. Another plant in our collection, *Crinum procerum* Carey var. *karawanum* has especially beautiful bronze-tinged, sword-shaped leaves. It is very similar in structure to the large bulbous crinums mentioned above.

Although some crinums are deciduous during dry periods, ours are all truly tropical and evergreen, retaining their leaves in the greenhouse throughout our winters. Nonetheless, water should be reduced in winter. They respond, as do watsonias, to a cool misting twice daily. They should be planted with their long necks above the soil.

The genus *Amorphophallus* of the arum family contains about 100 species and is native to tropical Asia and Africa. *Amorphophallus titanum* Becc. has tu-

bers that grow to an immense size. Each year in the spring the tuber will produce a single leaf composed of an erect, fleshy, gray and purple, spotted stalk and a spreading compound blade, much divided into leafy segments. The inflorescence appears before the leaf and is characteristic of the arum family with a spathe (a large leafy bract) that subtends the spadix (a spike of male and female flowers). *A. titanum* has never flowered at Denver Botanic Gardens; indeed only about six plants have ever bloomed in captivity in temperate regions. It reputedly has a foul odor that facilitates pollination by carrion insects. Soil should be kept moist all through the growing season, and foliage misted twice daily. During the winter the tubers are stored in their dry pots on the greenhouse shelf.

Lycoris, of the amaryllis family, is an eastern Asian genus native from Japan to the Himalayas. Its asymmetrical funnel-shaped flowers usually arise from the bulb before the plant is in foliage or after the leaves have died down.

The bright red flowers of *Lycoris radiata* Herb. appear in the fall. The dark, glaucous, linear leaves have a whitish center stripe that develops along with the flower or just after blooming. The six narrow, strongly reflexed petals are joined into a short perianth tube at their base. Flowers are borne, a few to many, on solid flowering stalks. It is common in Japan as a wildflower, but it is not cultivated there because tradition says it is "possessed of the soul of a dead person."

Lycoris aurea Herb. blooms in late summer, before its glaucous leaves appear. Flowers are golden yellow with reflexed, wavy petals. It ranges from Japan through China, Taiwan and Vietnam.

By June, lycoris leaves are turning yellow, signalling its dormant period. Water is gradually reduced until it is withheld altogether. The bulbs should be kept very hot and dry all during the summer months, and watering should be resumed again in autumn.

The tropical bulb collection at Denver Botanic Gardens is presently being revitalized. Future goals for the collection include the development of an educational exhibit featuring these plants and the ecological communities and plant associations of which they are a part.

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The Green Thumb
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The Green Thumb



Spring 1986

Volume Forty-three
Number One



The Cover

Vertical Garden

Frances Frakes Hansen

The Green Thumb

Spring 1986

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Velma A. Richards
Editor

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Morrison Center: Ideas to Treasure

by Bernice E. Petersen

Visitors strolling through the gardens at the Morrison Horticultural Demonstration Center (MHDC) soon discover a treasury of innovative landscaping ideas.

Specifically designed for accessibility for *all* people, the MHDC is the first regional horticultural therapy training center in the United States. Here visitors may explore a world of plants chosen to stimulate the senses and highlight the therapeutic versatility of plant materials in an outdoor environment.

In reality, within this limited space just north of the Denver Botanic Gardens parking area is a miniature botanical garden. Here are plants chosen for shade or sun, to touch or to smell. Here, too, are unusual trees, shrubs, perennials, groundcovers and ornamental grasses being tested for hardiness in our high plains, semidesert environment. These include Japanese maple, weeping larch, several hollies, lotus, magnolia, cypress and more.

Esthetically pleasing landscapes range from colorful hanging baskets and window boxes, to flue tiles and clay pots displayed singly or clustered; raised gardens are bordered with rocks, upright planks, ties, bricks—all intended to be tended by those with an abiding interest in hor-

ticulture yet sometimes limited in physical strength and agility.

Gardens have been planned and planted for shaded areas or dry landscapes. Color schemes have been selected for those who prefer everything in black and white, blue and green, even yellow, red and purple.

For those horticultural visionaries whose interests soar skyward, consider a floral tapestry of elfin impatiens, a blending of reds, white and pinks on a vertical wall garden—a visual delight lending privacy to a patio, providing a living screen to break the wind, hide an unsightly view, and best of all, a focal point in a landscape. Specifications include a drip irrigation system for some versions of the wall, others have shelves holding pots of flowers, herbs and vegetables.

Impatiens, fibrous and tuberous begonias, ferns and lobelias are naturals on the shaded side of the wall; petunias and some tomatoes, if protected from winds, have flourished or floundered with reflected light from our bright sunshine.

No room for a vegetable garden in your landscape? Again, the wall garden offers a solution. On a south exposure are pots of basil, sweet peppers, eggplant, cherry tomatoes and bush cucumbers. Ornamentals include portulaca, petunias, marigolds and those charming Thai peppers. For serious horticultural hobbyists with limited spaces, cactuses, sedums, distinctive varieties of hen-and-chicks as well as exquisite saxifrages and artistic

Bernice Petersen is a frequent contributor to *The Green Thumb*. Her articles on garden topics have also appeared in *Empire Magazine* of *The Denver Post* and *American Horticulturist*.



Morrison Horticultural Demonstration Center with silvery-gray touch garden in foreground.



bonsais can be used.

Outlining the Center's garden is a "sensory par course" leading to the fragrance garden and to the touch garden. Fragrance fanciers are often herb hobbyists or culinary artists as well. Under a canopy of trees along the southern section of MHDC grow pink rosemary, marjoram, bronze fennel, winter savory, chives, French celery, bay laurel, cardamom, lemon grass and lemon verbena and a large-leaf sage. Any fragrance garden would be incomplete without an assortment of scented geraniums in apple, chocolate, lemon, mint, camphor and rose. Spicy viburnum, blue elder and sweetly scented wild plum furnish height and texture to the background.

Wall garden forms a floral tapestry of elfin impatiens.

Eastward along the south pathway is the touch garden. These plants often offer soft, velvety foliage; sometimes the leaves are crisp or hairy, pleated or feathered, but essentially they are silvery-gray or gray-green in color. Many are aromatic—sweetly fragrant, others, pungent—the interpretation is personal.

Following are some of the many silvery-gray foliaged plants in the touch garden.

Anaphalis yedoensis, one of the pearly everlastings; its foliage is whitish-gray from a coating of cobwebby hairs. The small white heads of flowers often are cut before maturity, dried and sometimes dyed for everlastings.

Sages are grown chiefly for their foliage, their mostly yellow flowers are insignificant. Among those growing in the touch garden are *Artemisia absinthium* cv. Lambrook Silver, a tall subshrub; its white lacy foliage contrasts with *A. lactiflora*, a fine form of mugwort with greenish leaves and creamy-white flower heads. *A. stelleriana*, sometimes called beach wormwood, old woman, or a dusty miller, is a densely white wooly perennial about 2 feet high. *A. frigida*, fringed or pasture sagebrush, is common from plains to subalpine zones throughout the Rockies. This attractive plant with finely divided silvery leaves grows 9-15 inches high.

Cerastium bierbersteinii is a creeping perennial, sometimes overly aggressive, with slender grayish-wooly leaves. The comparatively large white blooms, similar in form to the native mouse-ear chickweed, appear in May or June.

Chrysanthemum densum, or *Tanacetum densum*, partridge feather, with coarsely textured but finely divided foliage is almost pleated or feathered. The name partridge feather is probably a gift of Homer Hill, a local plantsman. The plant spreads rapidly and is extremely popular at the Botanic Gardens Plant Sale. *Salvia argentea*, silver sage, has broad 8-10 inch long grayish-green leaves blanketed with prominent long silver-white hairs. Its tall flower stalks, sometimes 3 feet and branched, are con-

torted, almost grotesque, with off-white blossoms in a whorl.

Solanum marginatum, a spiny shrub growing 3 to 4 feet high, has 8-inch long greenish leaves densely white with hairs beneath. Both stems and leaves are thorny.

Stachys byzanthine cv. Silver Carpet is a distinguished variety of lamb's ear, distinguished because it is without seeds, but favored for its soft, velvety foliage.

Thymus pseudolanuginosus is a dainty, creeping wooly thyme excellent as edging, between rocks and in troughs.

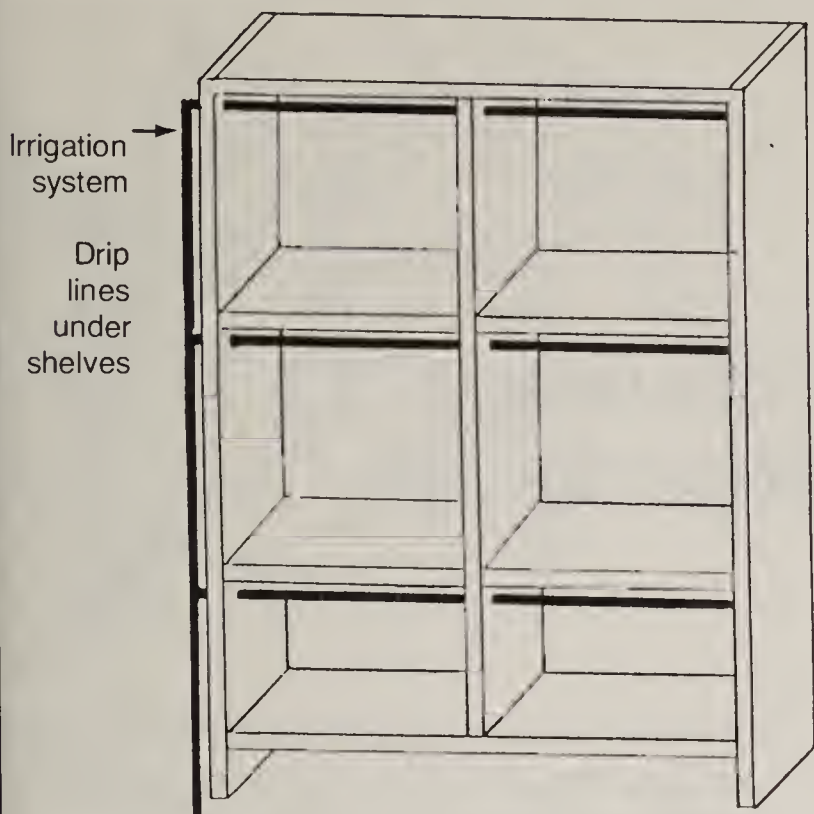
At the top of the knoll in the touch garden lemon lilies, hemerocallis, blossom in soft pastels and perky marigolds sparkle in plantings of dusty miller.

Across the walkway from the fragrance garden is a bed of *Santolina chamaecyparissus*, lavender cotton, with pungent foliage, soft and silvery with yellow button flowers. This compact shrublet is sometimes clipped for low formal hedging or is used in floral calendars and other symbols in public parks. Another small shrub is *Lavendula angustifolia* cv. Hidcote; the fragrant lavender flowers are descriptive of its perfume and are used in potpourri. Grandmothers tucked this favorite among linens.

Perhaps today's silver-gray garden will be tomorrow's Colorado landscape since many plants have adapted for drought tolerance with hairy foliage often gray. This preponderance of gray-foliaged plants in the touch garden rekindles a fascinating idea.

More than 30 years ago, M. Walter Pesman, a founder of Denver Botanic Gardens and prominent landscape architect, envisioned a silvery-gray garden. "Contrasted with our Colorado sky, and in keeping with a number of our native plants, it will be an attempt to make a Rocky Mountain garden fit the Rocky Mountain landscape as well as the Rocky Mountain climate. . . .

"Will the silvery-gray garden be monotonous? . . . Gray in one case, like green in the other, is merely the backdrop, the atmosphere of the scene. . . .

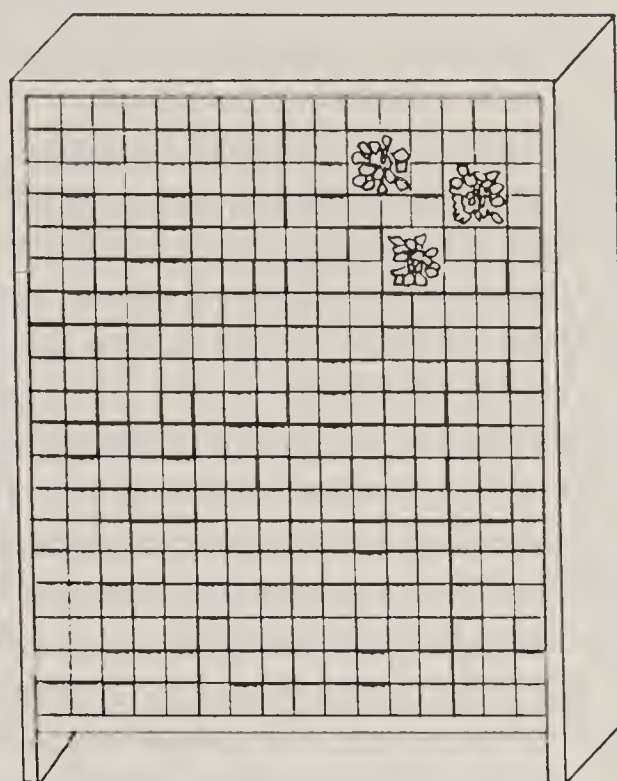


Vertical planter constructed with redwood lumber.

Adapt this design to fit your space requirements.

Inner shelves are not necessary if the planter is less than 4 feet high.

It may be from 4 to 10 inches deep, depending on height or whether it is free standing or attached.



Cover the front of the planter frame with 6 mil black plastic stapled to the frame.

Next, cover the plastic with hardware cloth (poultry wire works well) nailed to the planter frame.

If the planter has no shelves, remove the top board and fill with soil.

If shelves are used, fill and cover a section at a time.

Use wire cutters to cut small holes in the hardware cloth large enough for a transplant to be planted through a small hole in the plastic and into the planter's soil.

Vertical planter with drip irrigation system.

"Shall we use a gray groundcover instead of bluegrass?" he asked. "Rocky Mountain pussytoes for instance."

In conclusion Mr. Pesman assured readers of *The Green Thumb* magazine: "When we get that Rocky Mountain Botanical Garden in running order, more than likely a collection of grays and silvers will receive consideration. Before long this region will make its contribution to Garden Art comparable to that made by Italy, by England, by the Moors of Spain."

Long-time friends and co-workers of Walter Pesman who shared his enthusiasm and vision will be elated to find that with the touch garden at the Morri-

son Center, one of his dreams—a silvery-gray garden as a part of the Rocky Mountain landscape—is becoming reality.

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- Conversations with Judy Carrier, horticultural therapist, and Panayoti Kelaidis, curator of the Rock Alpine Garden, both at Denver Botanic Gardens.

EXOTICS OF COLORADO

Juniper, *Juniperus* spp.

by Helen Marsh Zeiner

A walk through any residential area will show you how important junipers (*Juniperus* spp.) are in home landscaping. They are adaptable for many uses; in part because of their size range from very low creepers to medium-sized trees, in part because of their foliage which provides year-around color.

Colorado native junipers and their cultivars are often planted, but exotic species from other countries have proven so successful that some of our best ornamentals come from this group.

Junipers differ from other coniferous evergreens because of the nature of their needles and their fleshy cones which are commonly referred to as juniper berries. Junipers have two kinds of needles or leaves: scale-like and appressed, or awl-like. Both types are often found on the same juniper, where the mature growth will have scale-like needles and the young growth will have awl-like needles.

Junipers are dioecious, only the pistillate plants produce berries. Juniper berries are formed when the fleshy scales of small cones coalesce to form a small berry-like cone, often blue but sometimes reddish brown. They are usually glaucous.

Because junipers are so popular, an infinite number of cultivars have been developed. Cultivars are difficult to identify

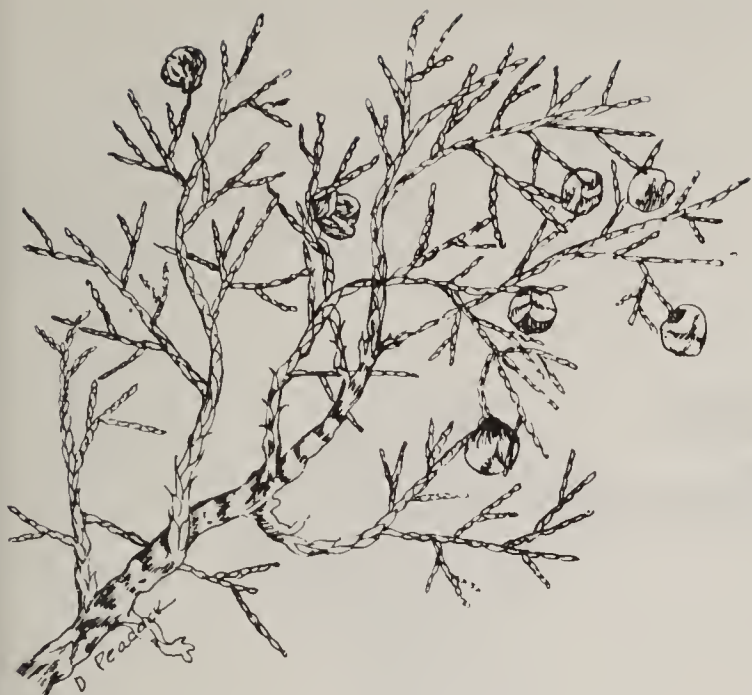
because of their very numbers and because one does not always have cones which are essential for identification. Many of the cultivars have been developed for color. There are many shades of green, while other junipers are blue or silver, making a nice contrast to other evergreens.

Denver Botanic Gardens is a good place to see and compare junipers. Growing there are about 80 different kinds including 12 species with numerous cultivars. For example, for *Juniperus chinensis* L. alone, 25 cultivars can be found. Some of the junipers at Denver Botanic Gardens are native to Colorado (*J. communis* L. and *J. scopulorum* Sarg., for example), but most are from other parts of the world as China, Japan, the Himalayas, southwest and central Europe, or from other parts of North America as Nova Scotia or eastern United States.

Some of the varieties of junipers grown at Denver Botanic Gardens have been popular for years; others are comparatively new.

In *The Green Thumb*, March-April 1956, a number of evergreens considered best for horticultural use in the Rocky Mountains were listed. This list included several exotic junipers which are still popular today and which can be seen at Denver Botanic Gardens. These are: Marshall creeping juniper, *Juniperus horizontalis* Moench cv. Marshall Creeper; Buffalo sabin juniper, *Juniperus sabina* L. cv. Buffalo; Pfitzer

Helen Marsh Zeiner, Ph.D, writes Exotics of Colorado as a regular feature in *The Green Thumb*.



Juniperus scopulorum with scale-like appressed leaves.



Juniperus communis with awl-shaped leaves.

juniper, *Juniperus chinensis* L. cv. Pfitzeriana; and Tamarix juniper, *Juniperus sabina* L. var. *tamariscifolia* Ait.

In 1961, Dr. James Feucht wrote in *The Green Thumb* that the Pfitzer juniper, *J. chinensis* L. cv. Pfitzeriana, was "probably the most widely used low-growing, spreading evergreen in Colorado." He also mentioned the Savin juniper, *Juniperus sabina* L., and its variety *J. sabina* L. *tamariscifolia* Ait., *Juniperus horizontalis* Moench, and *Juniperus squamata* Lamb. cv. Meyeri as all being popular and useful exotics.

Some important experimental work on evergreens has been done in Colorado. Robert E. More, at his home in Buffalo Park, Jefferson County, Colorado, had a collection of conifers from all parts of the world. His object was to determine those suitable for use in Colorado. He developed an area which was known as the Glenmore Arboretum. The arboretum began with five acres in 1933. Forty acres were added in 1950. Irrigation water was piped in to all the trees. In November of 1958, 262 varieties of conifers, including many junipers, were growing at Glenmore. Promising junipers were propagated vegetatively.

In 1958, Mr. More retired and moved to California. It was necessary for him to sell Glenmore. Unfortunately, no horticultural group in the state had the money to purchase the property, and

Glenmore passed into private ownership and the experimental work ceased.

A number of exotic junipers now growing at Denver Botanic Gardens were grown successfully at Glenmore Arboretum. These are: *Juniperus chinensis* L. cv. Ames, *Juniperus chinensis* L. cv. Hetzi, *Juniperus chinensis* L. cv. Iowa, *Juniperus chinensis* L. cv. Maney, *Juniperus chinensis* L. cv. Pfitzeriana, *Juniperus horizontalis* Moench cv. Blue Chip, *Juniperus horizontalis* Moench cv. Marshall Creeper, *Juniperus virginiana* L. cv. Canaertii.

In addition to their use in landscaping, junipers of sufficient size are used for fence posts, for lining closets and making cedar chests, for small articles, for pencils. An aromatic oil of some species is used in medicine. The edible fruits of some species are used to season game and in flavoring gin.

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Growing Sempervivums and Jovibarbas in Colorado

by Rod Haenni

Colorado's steppe conditions are perfect for growing the members of two well-known genera of the Crassulaceae—*Sempervivum* and *Jovibarba*, both commonly known as sempervivums. These plants are perhaps more familiar to most gardeners as hens-and-chicks; so named because the rosette habit of growth typically produces larger "hens" surrounded by smaller offsets or "chicks." Offsets are produced on stolons of varying length and may be abundant or almost nil depending on the species or hybrid. One species of *Jovibarba*, *J. heuffelii* (Schott) A. & D. Löve, does not form stolons but instead produces new rosettes from buds on the main rootstalk.

Rock gardeners in particular can take advantage of the wide palette of colors available in the sempervivums. All of the plants grow less than 3 inches high and the rosette leaves can vary tremendously in color, shape, and hirsuteness. Rock crevices and ledges are preferred habitats of most sempervivums so they are very well suited for rock garden cultivation. The Rock Alpine Garden at Denver Botanic Gardens has over 60 different species and varieties of sempervivums—

the best collection in the Rocky Mountain region. Someone desiring to see first hand the variety offered by the sempervivums should take a stroll through the Rock Alpine Garden.

Sempervivum vs. Jovibarba

The differences between these two genera are slight but consistent. *Sempervivum* flowers always have from 8 to 16 petals while *Jovibarba* flowers have either 6 or 7. *Jovibarba* flowers are usually some shade of yellow while *Sempervivum* flowers range from white to yellow, red, and purple. Both genera are monocarpic with individual rosettes dying after they bloom. Flowering is infrequent to almost non-existent in some species in cultivation so some other criteria are needed to help distinguish between the two genera. Three of the five *Jovibarba* species form small, tight rosettes with lanceolate leaves and numerous easily detached offsets (*J. allionii* (Jord. & Fourn.) D. A. Webb, *J. arenaria* (Koch) Opiz, and *J. hirta* (L.) Opiz). *J. heuffelii* is unique in its ability to form rosettes directly from the rootstock. This gives even a small cluster a distinctive appearance as the rosettes look somewhat mashed together. The fifth, *J. sobolifera* (Sims) Opiz, is the most common and the most frequently available from local nurseries. Rosettes are flattened, the leaves are dark green and very fleshy, and each rosette produces large quantities of easily detached offsets known as "rollers." Needless to

Rod Haenni, a past president of the Colorado Cactus and Succulent Society, became interested in cacti and other succulents while doing geological work in the Southwest. He has been growing them for the past ten years and owns and operates Winter Country Cacti.

say, this plant can quickly become a pest in a rock garden.

A substantial amount of taxonomic confusion exists within the sempervivums as natural hybrids are fairly common. Also, because of their wide

range, various geographical forms of the same species or variety were apt to receive new or different species names. Presently, sempervivum authorities recognize about 35-40 species with a total of about 100 species and varieties. No naturally occurring inter-generic hybrids between *Sempervivum* and *Jovibarba* are known. Geographical forms are abundant. *J. heuffelii*, for example, has about 20 collectible forms from different localities throughout its range. These forms differ chiefly in leaf color and shape as well as rosette size.

Sempervivum hybrids have been created by the thousands for the past 50 years. Of all the hybrids produced, probably less than 100 qualify as distinctive enough to be included in a collection. Not only do several identical hybrids have different names, but frequently geographic forms were given hybrid names. Access to a good reference collection is almost a necessity in order to sort through the morass of hybrid names.

Distribution of Sempervivum and Jovibarba

Both *Sempervivum* and *Jovibarba* are found as natives only in central and southern Europe and in adjoining portions of Russia, Turkey, Iran, and across the Strait of Gibraltar in Morocco. Both genera prefer mountainous habitats and grow at altitudes ranging from 3,000 feet to over 11,500 feet. The majority of sempervivums grow between 40 and 50 degrees north latitude under very similar conditions as exist here in Colorado. All of the sempervivum species are hardy in the Denver area and many are being successfully grown at 9,000 feet in Dillon and Vail. The Balkan countries of Albania, Bulgaria, Greece, and Yugoslavia represent the center of sempervivum distribution as well as the region with the greatest number of species. At least 14 species of *Sempervivum* and 1 species of *Jovibarba* (*J. heuffelii*) occur there. The Balkans quite probably represent the original area where sempervivums evolved and spread to the rest of their present-day range.



Jovibarba heuffelii

Growing Conditions

The Denver area's climate is nearly ideal for sempervivums. The combination of warm, sunny days and cool nights during the growing season produces optimum color in the leaves of the rosettes. The height of coloration occurs during late April to early May here. Colors can range through various shades of green, orange, red, violet, blue, purple, brown, and even yellow. Rock garden conditions provide the best opportunity to enjoy the plants in a semblance of their natural habitats but the sempervivums will grow in just about any well-drained soil. Some enthusiasts grow them in pots to prevent accidental hybridization and intermixing. A southeastern exposure seems to provide optimum light for sempervivums in Denver. Full south or west exposures tend to burn the plants and force the rosettes to close to preserve moisture. Too much shade will prevent the leaves from developing any color but green, as pigment production is stimulated by strong light. Rot caused by poor drainage seems to be the only serious problem sempervivums are subject to in the Denver area. Heavy clay soil should be avoided or amended to prevent drainage problems. Unless they are grown in pots, sempervivums should need supplemental water only during summer droughts. The plants will enter dormancy during November and begin new growth in late March to early April. Frost heaving can push young plants (and their labels) out of the ground but a top mulch of ½-1 inch of limestone or granite pea gravel can minimize this problem.

Sempervivums are very easy to propagate. Offsets need only to be separated and placed base down in the pre-moistened soil where they are to root. The offset will root and begin growing within two weeks. The only exception to this practice is with *J. heuffelii*. Because the rosettes sprout directly from the root system, propagation involves cutting the rosettes apart with a sharp knife. The cuttings must be allowed to callous over in a dry shady place before being replanted. One rosette can even be cut into

fourths for more rapid propagation.

Propagation by seed is risky and uncertain unless the plant involved has been hand pollinated. Seed from unprotected hybrid plants is only useful to those seeking to create new hybrids. Two different approaches to hybridizing are generally followed: Seed is collected from open pollinated plants and grown for one or two seasons and any strikingly different plants are saved while the remainder are discarded. The brightly colored rosettes must then be compared with other similar hybrids to determine if the "new" hybrid is distinctive enough to warrant a new hybrid name. Unfortunately, many hybrids have been produced and distributed that were unworthy to have been propagated on. The second more successful method involves hand pollinating the seed parent using pollen from a known pollen parent. Growing in pots in greenhouses is essential for this method to be worth the extra time and record keeping necessary. The large number of species, varieties, forms, and existing hybrids leaves plenty of opportunity for outstanding new hybrids to be produced.

The Sempervivum Society in England periodically evaluates new hybrids and determines which of those submitted deserve named status. The society also periodically notes outstanding new hybrids with either an award of merit, or their gold, silver, or bronze rosette awards.

Recommended Sempervivums and Jovibarbas

Here is a descriptive list of sempervivums and jovibarbas that are distinctive, colorful, and worth growing. The addresses of the two societies specializing in the study of sempervivums are included at the end of the list.

Sempervivum arachnoideum L. var. *arachnoideum* is found all through central Europe and south into Italy. The most desirable forms have individual rosettes less than ¼ inch across and are densely covered with "cobwebs" connecting the leaf tips. A very good trough plant.

Jovibarba arenaria (Koch) Opiz from Mur-tal in southern Austria forms small, tight globular rosettes with scarlet splashes of color on the outer leaves. Offsets are abundantly produced.

Sempervivum 'Blue Moon' has wonderful pubescent blue-green leaves in open rosettes about 3 inches across. Grows rapidly and offsets unselfishly.

Jovibarba 'Bronze Ingot' is one of the best *J. heuffelii* hybrids as the purplish-brown leaves are beautifully edged in gold. Slow growing and stays compact. The *J. heuffelii* hybrids are considered the cream of the sempervivum crop by connoisseurs as they have the widest range of leaf colors of any group of sempervivum hybrids.

Sempervivum 'Cebenese' is a larger *S. arachnoideum* hybrid that is so densely covered with cobwebs that leaves can hardly be seen. This hybrid will cover about a square foot of ground in two growing seasons.

Sempervivum ciliosum Craib var. *borisii* Degan & Urumor from Bulgaria is my personal favorite. Each leaf is fringed with silver hairs (cilia) that overlap in the small (1 inch) rosettes. Bright yellow flowers are borne on a short stalk and contrast nicely with the silver-green rosettes. This is a great trough or rock garden plant.

Sempervivum erythraeum Velen. is another Bulgarian beauty with purplish-gray leaves softened by fine white down. The rosettes are 2-3 inches across and offset freely.

Sempervivum x fauconnetti Reut. is a *S. tectorum x arachnoideum* hybrid of very small rosettes forming an orange and green carpet wherever it grows. Leaves have hairy tufts at their tips. An excellent trough plant.

Sempervivum 'Lavender and Old Lace' is a famous *S. tectorum* hybrid created by Helen Payne of Oakhill Gardens. Various shades of pink suffuse this plant's silver-lined leaves. Rosettes grow to 4 inches across and multiply rapidly.

Sempervivum 'Lipstick' is a dark red rosette that multiplies freely. The leaves keep their color through much of the year.



Jovibarba arenaria



Sempervivum arachnoideum



Sempervivum erythraeum

Sempervivum marmoreum Griseb. var. *dinaricum* Becker is from the Karawanken mountains of southern Austria. The leaves are edged in white hairs and have blood red tips. Lower portions of the leaves are brown and green. Rosettes are about 2 inches across and offset readily.

Sempervivum nevadense Wale is from the mountains of Spain. The rosettes turn scarlet when grown under natural conditions without additional fertilizer. This is a stunning plant when dozens of the 1 inch rosettes have grown together to produce a mass of color.

Sempervivum octopodes Turill var. *apetalum* Turill is an oddity from Yugoslavia. The rosettes are hairy and red-brown tipped. The stolons send offsets out in all directions up to 8 inches away from the parent. Individual rosettes are only an inch across.

Sempervivum 'Oddity' is a *S. tectorum* mutation with rolled leaves that look like pen quills. This plant does not flower and offsets freely. Individual rosettes can grow to 8 inches across with age.

Sempervivum 'Ohio Burgundy' is an outstanding *S. tectorum* hybrid. The combination of pubescence and rich burgundy coloring gives the effect of red velvet. Rosettes are large, 6 or more inches across. Offsets are moderately produced.

Sempervivum ossetiense Wale is a rare plant from the Caucasus Mountains in Russia. The rosettes are olive green with brown tips. Rosettes are 3 inches across and produce moderate amounts of offsets.



Sempervivum tectorum

Sempervivum 'Pink Lemonade' has yellow and pink leaves in a 3-4 inch rosette. Offsets are produced sparingly.

Sempervivum 'Pixie' is a delightful *S. arachnoideum* hybrid. Rosettes will form a low mound with age. Orange and green leaves with tufts of hair at the tips form 1 inch or smaller rosettes. A bit large for troughs but an excellent crevice plant in the rock garden.

Sempervivum 'Raspberry Ice' has pubescent silver and pink leaves in a medium rosette. A very attractive plant producing few offsets.

Sempervivum 'Ruby Heart' is a large *S. tectorum* hybrid with glowing red leaves. The red fades from the outer leaves after the spring peak of color but persists in the center of the rosette, hence the name. Rosettes offset freely and reach 6 inches across.

Information on the Sempervivum Fanciers Association Newsletter, issued quarterly, can be obtained by writing to:

Dr. C. William Nixon, Editor
37 Ox Bow Lane
Randolph, MA 02368

Information on The Sempervivum Society, issued three times a year, can be obtained by writing to:

The Sempervivum Society
11 Wingle Tye Road
Burgess Hill
West Sussex RH15 9HR
Great Britain

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Fruitful Landscaping

by Moras Shubert

As has been said, a house is not a home until it is landscaped. We instinctively want to have beautiful plantings, so we all too often go to the garden centers and nurseries and ask for the same monotonous list of plants without thinking about the interesting diversity which is available to us. Why not consider adding species which not only provide beauty of form and color but usable fruit as well?

The altered urban climate tends to be less rigorous than it was in the old days; now we can grow species and varieties of plants that did not do well previously. When I first came to Denver nearly 40 years ago I was advised not to waste time or space on several considered hardy today.

The purpose of this article is to stimulate interest in decorative fruit-producing plants. I am not proposing we eliminate those without edible fruit but suggesting how others may be incorporated into existing plantings. Some native species will be considered as well as some not native to the central Rocky Mountain region.

Many of the natives can be obtained by collecting fruits and planting the seeds either in containers or directly into the garden. With some plants, such as gooseberry, rooted side shoots can be taken without damaging the parent.

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Native Species

Chokecherry (*Prunus virginiana* L. var. *melanocarpa* (Nels.) Sarg.)

In spring the wonderful fragrance of blooming chokecherry bushes fills the air in the foothills; later they are laden with fruits good for jelly making. Why not use them as background plantings at home? Because they are easily started from seed, unwanted seedlings may come up in the garden and should be pulled while small to avoid a thicket.

Golden Currant (*Ribes aureum* Pursh)

Although the currants are not very palatable, birds like them, and the clove-scented golden flowers in early spring make this a good candidate for your garden. It is found along the woods' edge near streams in the lower foothills and is available at local nurseries.

Gooseberry (*Ribes inermis* Rydb.)

Another bush found in the lower foothills that can be used for fruit production as well as an effective fence is the native gooseberry. Although its species name *inermis* means unarmed or thornless, this is certainly a misnomer—the vicious, sharp thorns quite effectively discourage intruders.

So who wants to pick gooseberries if they are full of stickers? The answer: never pick gooseberries from the bush. Use leather gloves and pruning shears when the berries are ready—about the



Currants

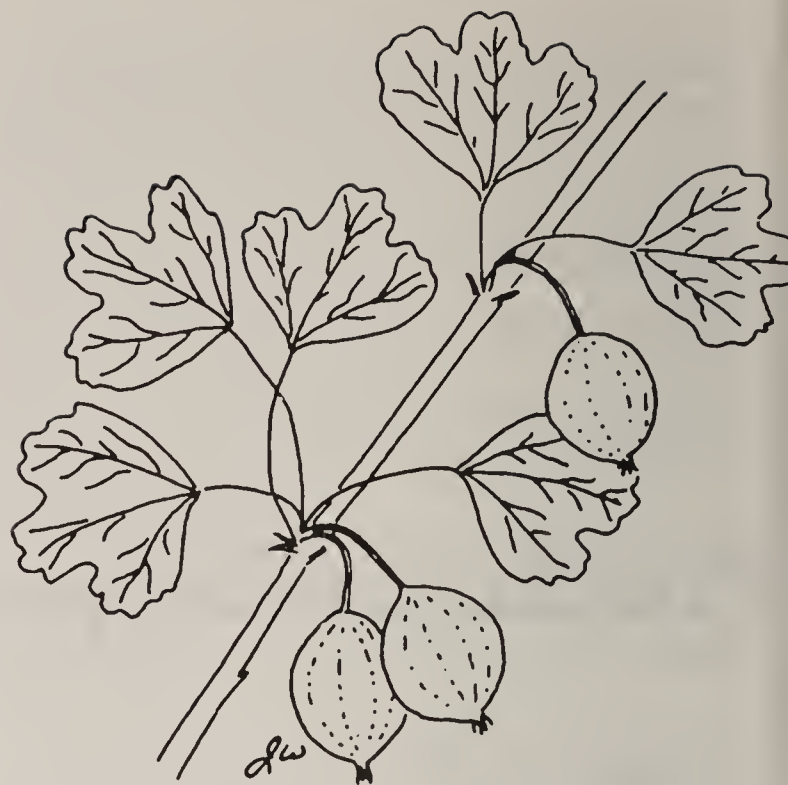
Fourth of July when they become a translucent amber color. Holding each fruiting branch by its tip, cut it off just below the place where the berries are found and carefully put those branches in a basket or garden cart. Take them to a comfortable place, sit down and, holding each branch with a gloved hand, pick the fruits. You should not get a scratch. Gooseberries and currants which are treated the same way are by far the easiest fruits to pick. This form of pruning encourages even more fruiting canes in succeeding years and a thicker growth of bushes.

Hawthorn (*Crataegus* spp.)

There are a few native species of hawthorns as well as many named varieties; all allegedly produce fruit usable for jelly making. Enjoy the colorful fruits for weeks before picking some for jelly juice, and birds and squirrels that frequent your garden will devour any that remain.

Oregon Grape (*Mahonia repens* (Lindl.) G. Don)

Neither from Oregon nor a grape, this native could as well be called "mahonia." These low-growing evergreen bushes make an attractive ground cover in semi-shade but do just as well in sunny locations. The clusters of blue berries are ready to pick about the middle of August. Jelly made from these fruits—as exotic-



Gooseberries

tasting as guava jelly—is a beautiful clear red-purple and great served with meats.

For those who have not made jelly from this native—a word of advice. When the fruit is heating prior to extracting the juice, it will smell like a poor grade of ink. Keep right on. Strain the juice, add a cup of sugar for each cup of juice and some very pure pectin. The flavor will be as delicious as it is unusual.

Plum (*Prunus americana* Marsh.)

In late summer along the roadsides of the lower canyons you often see people picking wild plums. The advantage of having your own wild plums is that they will be less troubled by insects and produce more succulent fruits, and you will have enjoyed the pleasant fragrance of their flowers in early spring. Save a few seeds from the wild and plant them along the back fence, but do keep them trimmed to develop attractive form.

Horticultural Fruits

The following species are not found growing natively, or the native species are not satisfactory for use.

Apple (*Malus sylvestris* Mill.)

Why do we not plant more good eating apples? Perhaps because people think the older varieties grow too large for home grounds. There are excellent dwarf varieties—actually the same fruits grafted on dwarfing stock. With these small trees the homeowner can pick the fruit without risking life or limb (no pun intended). The advertised multivarieties are seldom good choices. When more than one variety is grafted to a single stock, usually one thrives and the others lose out. It is best to select the varieties that please you most. Choose for early, mid-season or late, and for color and flavor that suits best.

Crabapple (*Malus baccata* Borkh. and others)

Crabapples are popular for their early flowering, but seldom is much thought given to choosing the edible fruit varieties. A stroll along the east-west walkway just south of the Denver Botanic Gardens Conservatory during summer will give some idea of the beautiful fruits that may be used later for tasty jelly. The usual abundance of fruit means there will be food left for the birds and squirrels.

Cherry (*Prunus cerasus* L.)

This is the common sour or pie cherry, but other species may be considered. Although robins may get more of the fruit than the homeowner, there is a lot of pleasure (or sorrow) in watching the birds gobble the fruit. Cherries available for picking can be made into most delicious pies or preserves.

Elderberry (*Sambucus canadensis* L.)

This native of eastern United States could be used more often. From the time the large doilies of flower clusters form until the dark red—nearly black—fruits are ripe, this can be an attractive shrub. The flower clusters (just a few of them, if you want fruit) can be dipped in egg bat-

ter and fried to make fritters. Later when the fruit is ripe—often in abundance—fruit soups and jellies can be made. Both may be improved by adding lemon juice to increase acidity. Don't forget to use a pure pectin for jelly.

Grape (*Vitis labrusca* L., *V. vinifera* L. and hybrids)

Planted on a trellis, fence or pergola, grapes will be beautiful, and the fruit will be flavorful and bountiful. Grapes are so easy to grow and need so little attention that anyone can have them. They should be severely pruned each year, about February if weather permits, and securely fastened to their support. White flies can be pests during the hot dry period. For control use a strong force of water preferably with some liquid soap or detergent added. Do try some of the newer varieties rather than just the old favorite 'Concord.' Visit the grape arbor in the herb garden at Denver Botanic Gardens about mid-September to study the many varieties there. Vines are labeled on the support posts to assist in making selections.

Nanking Cherry (*Prunus tomentosa* Thunb.)

Before the leaves emerge, this choice shrub flowers with white petals and reddish calyx giving the impression of light pink blossoms. Flowers form on the main stems, which should be pruned each year



Grapes



Red Raspberries

to encourage renewal. The small red fruits ripen in August and are of superb flavor for eating out of hand or for jelly. The plentiful fruit ensures that the birds do not get all of them. Most of the Nan-king cherries in our neighborhood are volunteers from seeds, but there is no problem about their being weeds—just dig them up and plant them where you want them or destroy the unwanted ones.

Quince (*Chaenomeles* spp.)

Called Japanese quince, flowering quince and Chinese quince, these small, mostly evergreen shrubs bloom very early in spring with lovely blossoms in various shades of red and pink. If several kinds are planted for cross-pollination, fruits will form. These should be picked shortly before frost. There are usually many shrubs with fruit on the berm south of the greenhouses at the Gardens. Fruits can be used the same way non-hardy tree quince is used. The jelly is even more flavorful and aromatic.

Raspberry (*Rubus idaeus* L.)

Our favorite homegrown fruit is red raspberry. Our plants are progeny from those planted 30 years ago. Once started, the plants renew themselves by root-sprouts, so by removing the old canes the plants that are growing each year are essentially no more than two years old. With only a little care—tying the canes to stakes or a trellis and pruning out the oldest ones—a small patch will produce



Strawberries

berries for more than a month during early to midsummer. If frost doesn't come too early there will be more berries to pick in September right up to freezing. For raspberries "large enough to stuff" use plenty of high-phosphate fertilizer, such as 5-10-5, and abundant water during the fruiting period. Do not use organic mulches on the raspberry soil; they do best in mineral soil.

Strawberries (*Fragaria virginiana* Duchesne)

Planted in a strawberry barrel or a planter with enough soil to support good growth, this delicious fruit can be an attractive focal point at the edge of an outdoor patio. Growing strawberries above the soil lessens the chance for our ever-present slugs to damage the fruit, and even robins cannot reach them so easily. Like raspberries, these plants need mineral soil and much high-phosphate fertilizer plus a good water supply. There are many varieties to choose from; especially desirable are the ever-bearing ones, which should really be called early-late season since fruiting does not occur during the midsummer weeks.

Many fruit-producing trees, shrubs and herbaceous plants have not been listed; we encourage readers to make suggestions. Nut producing trees and shrubs such as black walnut, hickory (seldom seen in the West but hardy here) and hazelnut bushes, can also be part of a fruitful landscape.

KNOWING—GROWING—CONSERVING NATIVE PLANTS Colorado's Great Natural Diversity

by James R. Trammell, Jr. and Victorine Mae Trammell

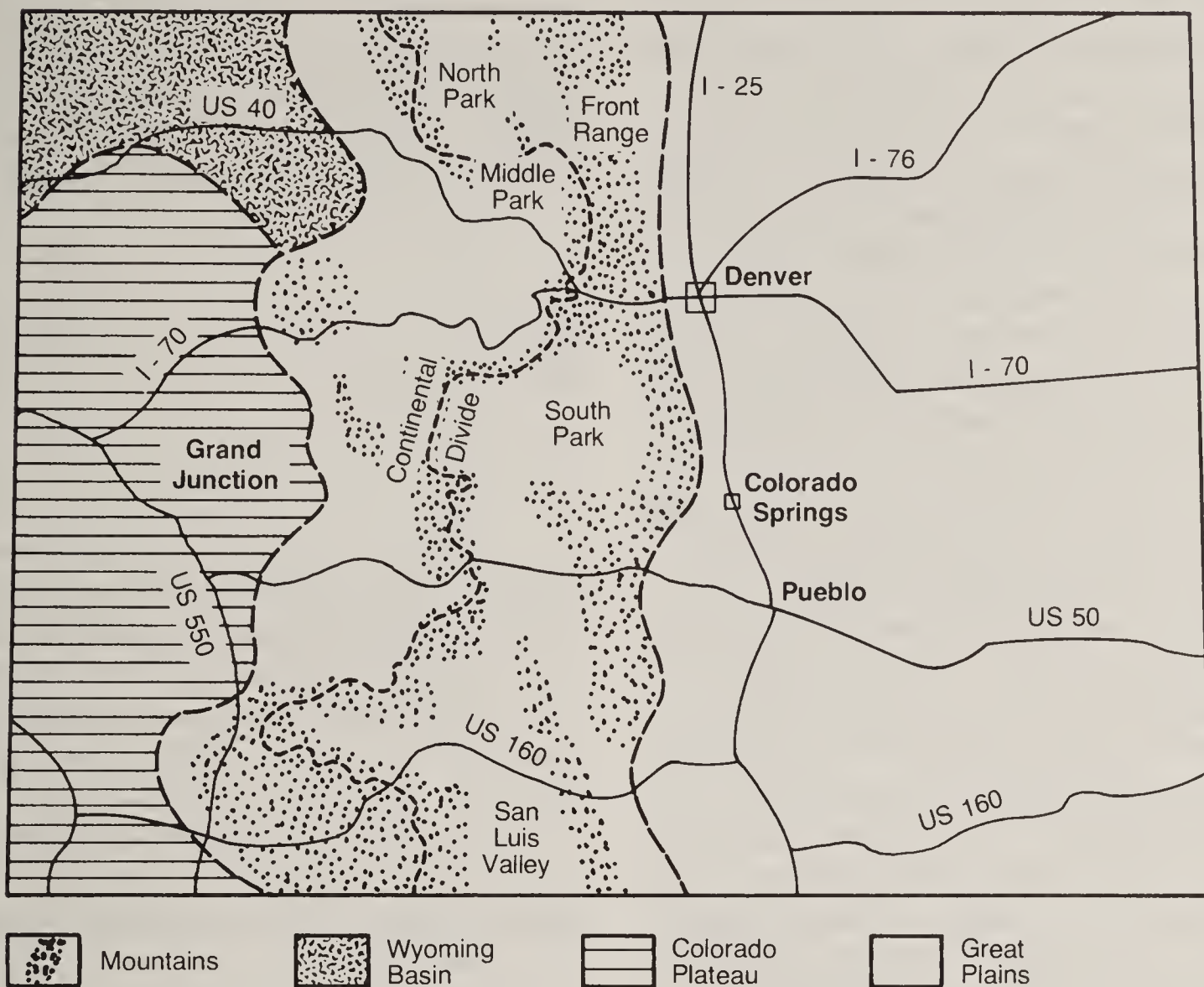


Fig 1. Major physiographic regions of Colorado.

With this issue, *The Green Thumb* embarks on a series of articles about the native plants of Colorado. The overall theme is "Knowing—Growing—Conserving Native Plants." Colorado's rich physiographic diversity creates habitats for literally thousands of different species of plants. Presented here is an

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overview of the various habitat types to be considered in the series.

Colorado can be divided into several physiographic regions based on elevation and geology. The map (Fig. 1) depicts the regions, major mountain ranges, parks and plateaus. The articles will be organized by habitat, which is not necessarily the same as physiographic region. As an example, wetland habitats are found in all physiographic regions. This approach fosters an understanding of the physical environment central to a better understanding of the native flora. The habitats that will be featured are: plains grasslands, canyons and mesas, forests, mountain parks and meadows, wetlands, barrens, and alpine tundra.

The Plains Grassland

The eastern third of Colorado is covered with short grass prairie. The area is part of the vast American intracontinental grassland that extends from the mountains of the West to the eastern deciduous forest, and from the boreal forests of the north to the Gulf coast and the subtropical vegetation of Mexico. To the travelers of the last century, it was the "great American desert." To the travelers of today it is the barren and boring land that must be endured while they speed eastward along I-70. But for those who venture beyond their cars—out onto the grassland—a surprise is in store, for this land is far from barren and boring. It is diverse, beautiful and very vulnerable.

Conditions are harsh in the Colorado grasslands. Summers are dry, warm and sunny. Winters are dry and cold. Precipitation averages below 20 inches a year with most coming as rain in the spring and summer. Weather can be violent. Summer afternoon thunderstorms are sometimes accompanied by devastating hail and tornados. Wind constantly blows. During the hot summer days, the combination of high wind and temperatures and low humidity produce drought. During the winter the wind causes drifting snow and blizzard conditions.

Topography is more varied than one might first expect. Flat plains, rolling hills, steep-sided mesas and solitary sandstone spires create specific habitats for a variety of plant communities. Soils have developed primarily from water washed or windblown materials. Some are well developed, old, fine textured loams, but these rich soil types are better developed east of Colorado. Many soils are younger and are sandy or cobbly. Because of low precipitation, salts are not leached downward, but collect several feet below the soil. This impervious band is called the caliche layer—or hard pan. A typical prairie soil profile, showing the caliche layer, is found in Fig. 2. In shallow depressions, where rain water stands, these alkaline soils are drawn to the surface by evaporation of water. These areas of alkaline soil create yet

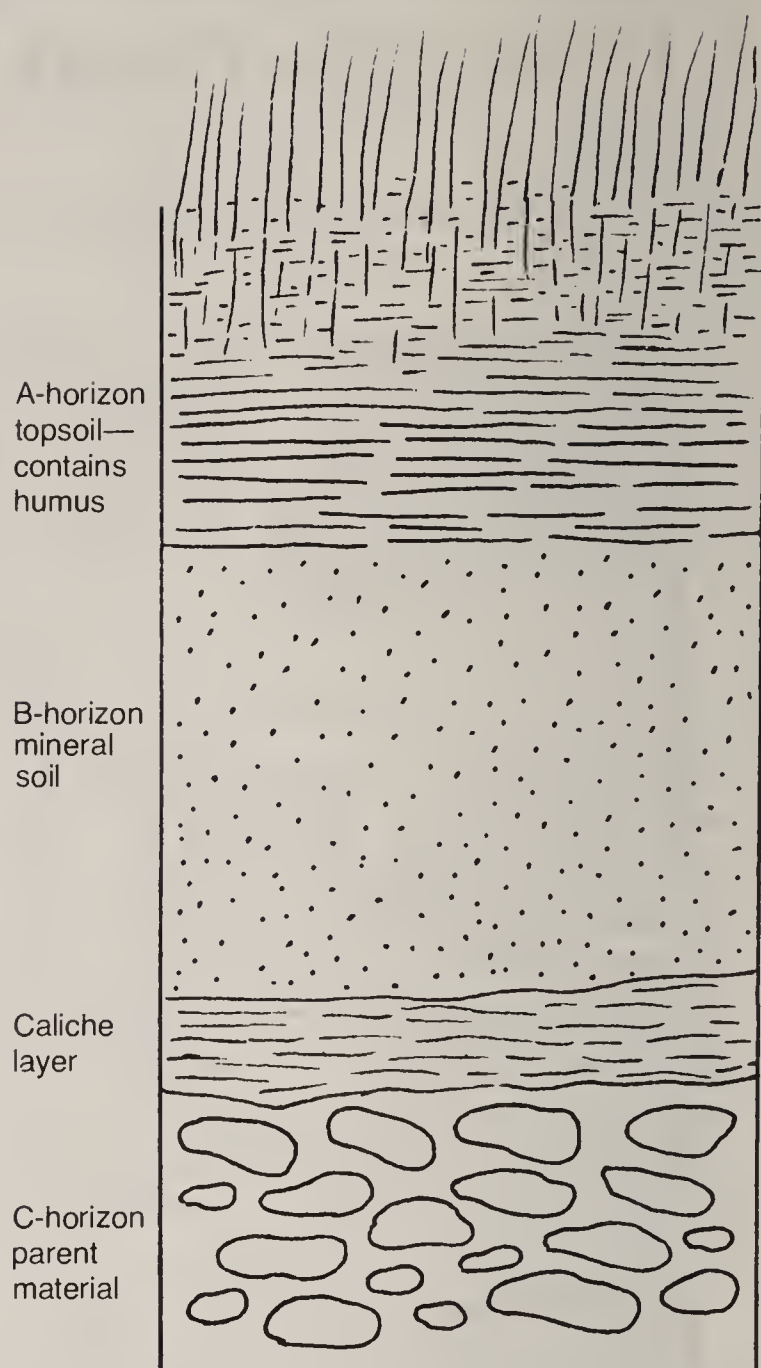


Fig. 2. A typical prairie soil profile showing the caliche layer.

another habitat—the salt flats.

Grasses are the dominant vegetation of the plains. They are beautifully adapted to the uncertain moisture and harsh weather conditions. The two climax grasses of the shortgrass prairie are blue grama and buffalo grass. These are perennial sod-forming grasses with widespread fibrous root systems. They can absorb water from the short-lived summer thunderstorm that doesn't penetrate very deeply into the soil.

The growing points of grasses are often close to the ground or underground. This protects the plant's future growth from the sudden changes in temperature, the drying winds, and grass fires that are part of the prairie environment. The fires burn off thatch, release minerals, and destroy shrubs and weedy plants. The grasses survive (if the fire is quick moving)

and, lacking competition, grow with renewed vigor.

Other types of plants are found. Moist sites that have not been overgrazed support perennial bunch grasses such as needle and thread and western wheatgrass. In areas where the native grasses have been destroyed by overgrazing or erosion, annual grasses such as cheatgrass and weedy herbaceous plants like Russian thistle, invade. Shrubs—rabbit brush and snakeweed—and perennials like yucca also indicate disturbed soil. Succession—the process of one community replacing another—does occur in the eastern parts of Colorado, but usually doesn't get a chance to complete the cycle, because of the constant disturbance of plowing and grazing. A typical succession of communities might first be pioneer plants like Russian thistle, pigweed, and amaranth. Several years later annual grasses like foxtail barley and cheatgrass will invade. The appearance of the climax perennial grasses often takes 20 to 40 years or longer.

Canyons and Mesas

Our approach to the organization of this series is not completely by altitudinal zonation, although we do have a section for the plains grasslands and the tundra, which are partly defined by their altitudes. Habitats are areas that have certain similar physical characteristics—such as limited available water. Similar habitats present similar problems to the plant communities that live in them. Canyons and mesas can be found at any altitude, from the steep arroyos and flat topped mesas of the great plains to the steep sides of glacial cirques in the tundra. The overriding physical condition here is topography. The sudden steepness intensifies erosion, sets up conditions for rapid percolation of water off the slopes and creates opposing slopes (north-facing vs. south-facing) that can support radically different plant communities.

Most of the canyon and mesa habitats are found in two locations in the state: the transition zone at the base of mountain

ranges and in the lower foothills of those ranges, and in the plateau areas of the western part of the state. The types of plant communities found on the mesas and canyons depend primarily on location in the state, altitude, and availability of water. Most of these areas contain shrublands or woodlands. The broken, eroded, arid land of the western plateau supports semidesert shrubs such as greasewood at lower altitudes (4000 to 6000 ft.). These shrublands grade into piñon-juniper woodland at higher elevation (4000 to 9000 ft.). This is the dominant plant community of the southwest part of the state, with its deep canyons and high mesas. One only has to visit Mesa Verde to see the piñon-juniper woodland in all its glory and historic importance.

Mountain shrublands are found where prairie meets the mountains on the eastern slope of the Rockies. The sandstone outcroppings of the Dakota hogback, Lyons Formation, and Fountain Formation create habitats that support Gambel's oak and mountain mahogany. These mountain shrublands intergrade into the ponderosa pine forests of the foothills and montane zones. Crystalline rock of the foothills is dissected by mighty canyons that direct their rivers and streams to the plains below. The steep opposing sides of these canyons create north and south-facing communities. In the canyons west of Denver, the cool north-facing slopes support dense stands of Douglas-fir while on the warmer, drier south-facing slopes, juniper, and at higher elevations, ponderosa pine grows.

Forests

The previous section mentions shrublands and woodlands (as opposed to forests). John Emerick (1984) makes this distinction between a shrub and a tree: If you need to walk around it, it's a shrub, if you can walk under it, it's a tree. Of course, there are many exceptions. Most people would describe the piñon-juniper community of southwest Colorado as a forest. It really is a woodland because the trees are small, shrubby and not densely

placed. True forests in Colorado are found in mountain areas where the elevation and available moisture are greater. They are named after their dominant tree species.

Ponderosa pine forests are found on dry sunny slopes from elevations of 5,600 ft. up to 9,000 ft. This forest type is dominant in the foothill and montane zones. South of Colorado Springs and on the western slope, it intergrades into the piñon-juniper woodlands of lower elevations. On the east slope of the Rockies, it meets the mountain shrublands at its lower borders. The most extensive ponderosa pine forests are found east of the Continental Divide. In northwest Colorado, ponderosa pine is not common. Similar habitats here are occupied by Douglas-fir. In fact, Douglas-fir often shares the same general area with ponderosa pine but inhabits cooler, more moist north-east facing areas. The habitat for ponderosa pine is relatively dry and warm, although not as dry or warm as that for piñon-juniper or mountain shrub. Annual precipitation is low (25 inches or less) and most falls as spring snow. A mature ponderosa pine forest is more like a savannah, with large trees scattered in grassy meadows. In the past fire has played an important role in the maintenance of this savannah-like habitat. Periodic grass fires destroyed shrubs and seedlings but encouraged grass growth and didn't harm the large trees, because of their thick bark. Where trees are dense, there are less grass and shrubs.

As elevation increases, ponderosa stands become more dense and Douglas-fir stands increase in number. At an elevation of 9,000 to 10,000 feet, the montane forest meets the Englemann spruce-subalpine fir forests of the subalpine life zone. The spruce-fir forest forms the highest and most continuous forest in Colorado. Because of high altitude and harsh weather, these areas remained undisturbed until recently. Even now, a few virgin areas can be found. The habitat is cool, moist and windy. This forest type is the state's "snow accumulation area."

Snow falls earlier, is deeper and stays longer than any other place. Because of this, the forests have a dark, moist, humid feeling. Soils are highly variable. Some are formed from glacial deposits. They are mostly young soils. Young firs and spruce reproduce under the shade of parent trees, thus ensuring the presence of spruce-fir forests for generations to come.

If the spruce-fir forest is destroyed by fire or logging, other tree species eventually invade as part of a succession of communities to occupy the site. What invades depends on the physical conditions of the site, the altitude, and availability of parent seed trees. After the original forest is destroyed (Douglas-fir at lower elevations and subalpine fir and spruce higher) the sunny exposed spot is quickly invaded by the successional forest type. The invasion takes five to ten years and reaches maximum density within 25 to 50 years. Because these successional trees can't reproduce under shade, they start to die out. Meanwhile, seedlings of the previous tree types grow large enough to continue shading out the invaders and, eventually, a climax Douglas-fir or spruce-fir forest has reestablished itself.

If the elevation is between 8,000 and 10,000 feet and if the location is moist and protected, the invader might well be aspen. Aspen is the only deciduous forest tree in Colorado. All other deciduous trees, for example, cottonwoods, grow in narrow belts along water ways. Although there must be cases of aspen growing from seed in the wild, this is very rare. Most aspens come from underground stems called rhizomes and are connected to other aspens. All the aspens in one grove could possibly be part of one tree. Aspen groves are very rich in both plant and animal life.

The aspen grove contrasts with the other successional forest type—lodgepole pine. These pines will invade after a fire, because the heat is needed to open the cones. Like aspen, lodgepole pine needs open sunlight to invade and grow. The lodgepole trees are usually the same size

and age in a given area. In fact, it is possible to date the fire that destroyed the original forest by dating the pines.

Lodgepoles grow densely together. There is little understory and very few animals. Some people refer to lodgepole forests as "biological deserts." Like the aspen groves, the lodgepole pine forests will be shaded out by the growing spruces and firs and will eventually be replaced if no other disturbance occurs. Sometimes aspen and lodgepole mix at the site of an old fire. More often, however, relatively pure stands are found side by side.

Lodgepoles are most commonly found between 8,500 and 10,000 feet, slightly higher than aspen. Lodgepoles prefer drier sites than aspen, with rocky shallow soil. Although lodgepole is considered to be a successional tree, some stands may be climax because young lodgepoles do reproduce under the older ones if the stand is not dense and is too hot and dry for Douglas-fir.

One other forest type is found in Colorado, but only in very specific habitats. If the site is between 7,500 feet and 11,500 feet, is very windy and rocky, and if snow is blown off during the winter, it might support limber pine, bristlecone pine, or a mixture of both. Limber pine is more common north of Berthoud Pass and bristlecone, south. The two mix west of Denver.

Mountain Parks and Meadows

Mixed among the mountain forests are open areas where the dominant vegetation is grasses, sedges and wildflowers. Trees and shrubs do grow here, but are widely scattered. The main difference between a park and a meadow is size. Parks are very large treeless areas between mountain ranges. Meadows are smaller. There are various types of grassy areas in the mountains: natural dry meadows, natural wet meadows, successional meadows and mountain grasslands or parks.

A meadow is considered natural if it remains a meadow for a very long period of time and if trees are not invading. Meadows exist on gentle slopes or in ba-

sins where deep, fine-textured soils that are either very wet or very dry have accumulated. Most foothill meadows are dry. A combination of deep, fine textured soil, lack of water and warm temperatures make tree growth difficult. Shrubs could survive but can't compete if the grass cover is dense. Seeds of tree species cannot get started because of thick thatch. The area remains a dry meadow as long as nothing destroys the grass.

Wet natural meadows are found mostly at higher elevations, in the subalpine. In the montane both types exist, depending on site characteristics. The wet meadows also have deep fine textured soils rich in organic material. The water table is high and late spring floods are common. Soils are saturated with water during most times of the year. Because of the wet deep soils and lush herbaceous vegetation, trees cannot invade and the site remains a meadow, with scattered trees and shrubs (usually willows). Successional meadows can be either dry or wet. They exist because the original forests were destroyed by fire or logging. The area will be invaded by successional forest types and then by the climax trees of the area. Successional meadows will become forest areas.

Mountain grasslands (parks) are found where fine deep soil, low available moisture and cold temperatures make tree growth difficult. Because of the high elevation of most of these parks, summer temperatures are cool. Winter temperatures are very cold, due to cold air drainage from surrounding mountain ranges. Some well known mountain grassland parks are North Park, Middle Park, South Park, and Estes Park.

Wetlands

In a state as dry as Colorado, water is precious. Availability of water affects all aspects of our lives and will determine growth and development in the future. The wetlands of Colorado are the smallest habitat type to be featured in this series of articles. Yet these very habitats are subject to the greatest impact by human interference. Streams are chan-

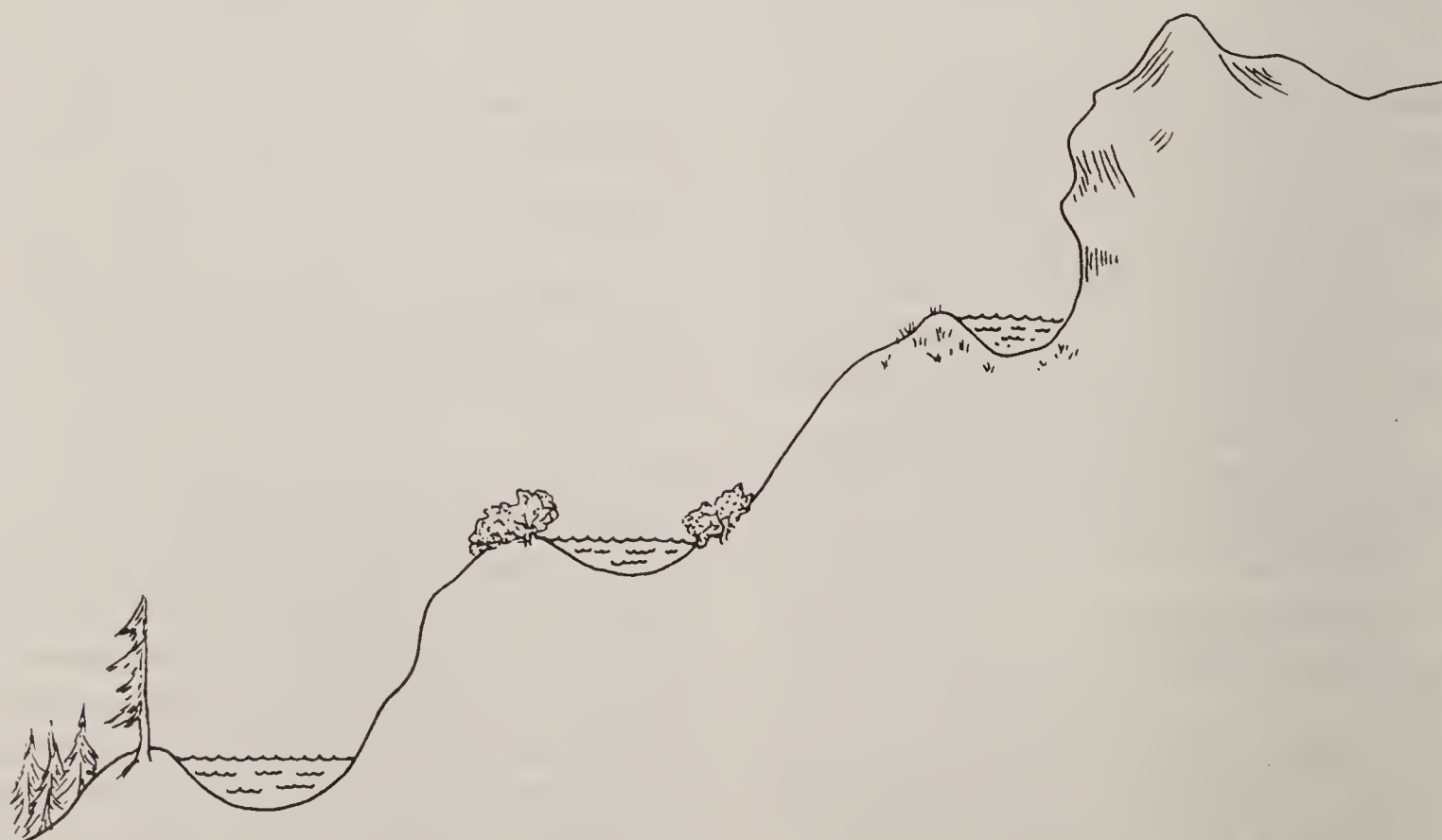
neled; marshes are drained; willow thickets are turned into hay fields; water is diverted to the metropolitan eastern slope; the beaver are trapped. Man also makes new wetland habitats by building artificial lakes and reservoirs. In a sense, wetland habitats are not so much destroyed entirely as moved around to other places.

Wetlands are found in all altitudinal zones. Their unifying characteristic is an ample and almost continuous supply of water. The average temperature of a wetland is usually lower than the surrounding areas because of cold air drainage, more humidity and evaporation, and shade of large deciduous trees. Soils vary from fine silts through sand, coarse gravel, and cobbles (pebbles). Flooding is common. Riparian means streamside. Lowland riparian communities are found along streams in the eastern plains and the semidesert areas of western Colorado. They have the lowest elevation of any wetland habitat in the state. Their vegetation is very different from the surrounding areas of grassland or semidesert shrub. Cottonwoods, peachleaf willow, boxelder, American elm, green ash and Russian olive are common. Lowland riparian habitats form a continuum with mountain riparian

habitats as one travels upstream into the mountains. The cottonwoods of the lower habitat extend into the foothills but are soon replaced by alder and riverbirch. Colorado blue spruce and white fir are two majestic conifers found in mountain riparian communities.

Lakes, ponds and marshes are other wetland types. They are short lived in a geologic sense and go through wetland succession from lake (pond) to shallow lake to marsh to meadow. The difference between a lake and a pond is arbitrary. Lakes are so deep in the middle that rooted vegetation cannot grow. Ponds have rooted plants all the way across. Locally, however, the terms are interchanged. Natural lakes are rare below the subalpine life zone. High mountain lakes are deep, clear and cold. Many were left behind when mountain glaciers retreated at the end of the last ice age. They often formed a series of "hanging lakes"—the highest one in a glacial cirque and the others found following the path of the long melted glacier (Fig. 3). They are connected by rushing mountain streams. Bank vegetation consists of grasses, sedges, wildflowers and willows and is similar to the mountain riparian vegetation.

Low elevation lakes and ponds are



often manmade, but if the water level doesn't fluctuate much, natural lake-margin vegetation can develop and the lake will go through succession if left alone. Reservoirs present a unique problem—fluctuating water levels. Although the lake margin vegetation typical of the area tries to invade, the rise and fall of water level makes it difficult. The banks of reservoirs are constantly being disturbed and usually support weedy vegetation.

Marshes are wetlands that don't have open water. They have emergent vegetation (cattails at lower elevations) growing all the way across. Marshes are one of the successional communities of wetland succession. The area was at one time a lake or pond, and will become a meadow sometime in the future. Marshes are extremely important for wildlife. The draining of marshes in populated areas is an irreplaceable loss of important habitat.

Barrens—Hazardous Habitats

The wetlands are lush. They support a greater species diversity than most other habitats in Colorado. The barrens are at the opposite end of the scale. Because of harsh physical conditions very few plants grow, but those that do are beautifully adapted to the hazardous habitat. In fact, many of the endemic, rare or endangered plant species of Colorado are found only in habitats that can be described as barren. This is precisely why these habitats are interesting and important. Barrens exist at all altitudinal zones and in all physiographic areas of Colorado. They are due to extreme soil conditions and topography. Species diversity is low and cover is sparse. On the eastern plains and in the western semideserts, alkaline flats can be considered "barrens." The Piceance Basin, with its rough topography, dry climate and severe erosion, is an excellent and well studied example. Barrens habitats are in danger. The Piceance Basin is the site of extensive oil and gas development. The general public thinks barrens are not pretty so there is no need to save them for "scenery." How-

ever, since most of our rare and endangered species grow in these hazardous habitats, they are, indeed, in prime need of protection.

Alpine Tundra

The alpine tundra lies above the tree limit on high mountains. The upper limit at which trees can survive can be anywhere from 11,200 feet to 12,000 feet elevation, depending on physical conditions. As one increases in altitude from the subalpine forest, the conformation of the trees starts to change, but the species don't. The subalpine firs and Englemann spruces are shorter, the branches are shorter, and the trunks are larger in proportion to the branches. More mountain meadows appear, often containing tundra plants. The trees take on a "flagged" appearance with branching only on the leeward side. They begin to grow in clusters called tree islands. Above the flagged trees, one finds trees that are almost prostrate, as if they are creeping along the ground trying to get out of the wind. These are the krummholz—the "crooked wood." These krummholz islands are at tree limit. Above this is the "land above the trees"—the alpine tundra. Fig. 4 depicts different kinds of tree limit forms.

The alpine tundra has a harsh environment. The frost-free time is 1½ months or less and snow can be expected anytime. Forty inches of precipitation usually falls during the year but much of it is blown down to the snow accumulation areas of the subalpine forest and is not available to the tundra plants. Wind often exceeds 100 miles an hour. It is wind desiccation combined with ice blasting and cold temperatures that kill the trees and create the tree limit.

The tundra habitat is diverse. Physical conditions—topography, aspect (direction the slope faces), soil types, available moisture—change quickly and very different plant communities exist just feet from each other. These communities can be very small, only several feet in diameter.

Tundra plants have many ways of adapting to the harsh conditions. Most

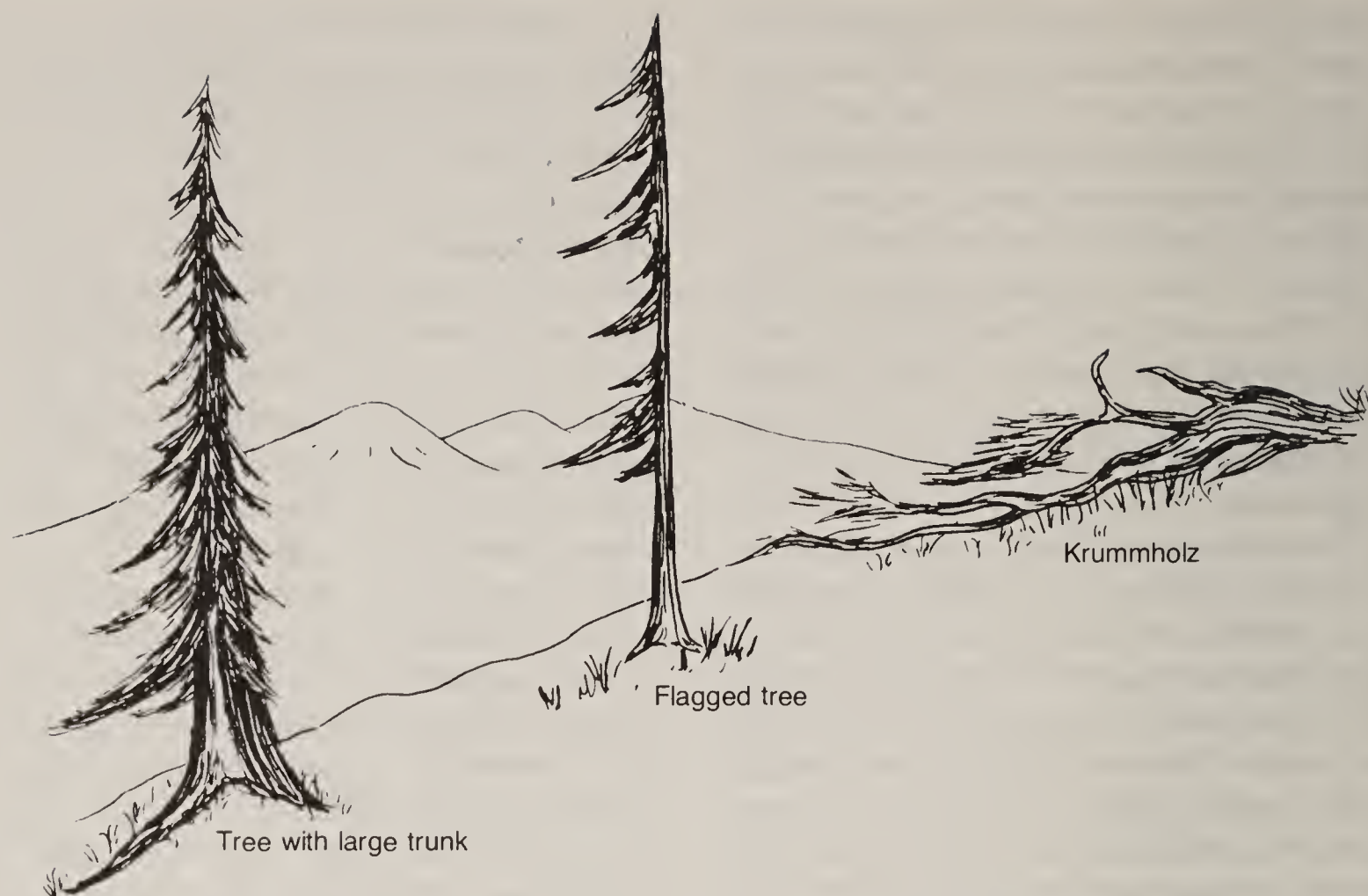


Fig. 4. Tree shapes in the transition between the subalpine forest and the alpine tundra.

are perennial so that if they don't have time to set seed one year they can still survive. They rely on vegetative reproduction—bulbs, rhizomes, runners, or bulblets. Many grow as little round cushions. This growth form conserves heat and water. Some plants have succulent leaves for water storage. Others have a red pigment (anthocyanin) that acts as "antifreeze." A good deal of research has been done in tundra areas and the articles devoted to this habitat will present much valuable information.

In our continuing series of articles about Colorado's native plants, we hope

to enable our readers to observe and enjoy them in their natural settings, to learn of their possible uses in landscaping, and to become aware of their need for protection from man's often destructive intrusion into their natural habitats.

Specific data and other technical information have come from the book *From Grassland to Glacier* by Cornelia Fleischer Mutel and John C. Emerick (1984). Most of the interpretations, descriptions and reflections come from our twenty-some years of study, research, travel and camping in Colorado.

KNOWING—GROWING—CONSERVING NATIVE PLANTS

Red Rocks Park In Early Spring

by Mary Edwards

In late February, when winter seems never-ending, days are still too short, winds are raw and snow is deep, have you longed for spring, for a hike in the foothills, perhaps to discover the earliest spring wildflowers? But if you live in the Denver area, you need not wait until spring is officially here! Plan a visit on a sunny morning in late February (some years of unusually warm winters, even late January!) to Red Rocks Park near Morrison just west of Denver. Search at the base of the massive red monoliths in south-facing crannies and you may find evergreen clumps of Oregon grape (*Mahonia repens* (Lindl.) G. Don) with clusters of flower buds just beginning to open a brilliant yellow.

Red Rocks Park is a part of the Denver Mountain Park system and was established in 1935. It is best known for its natural amphitheater set in spectacular formations of tilted red rock which form a dramatic setting for summer concerts. Because of the varied terrain of the park, it is a preserve for and fine example of the native vegetation of the foothills and lower montane zone of eastern Colorado. The altitude varies from about 6000 feet at the parking areas to 7800 feet at the top of Mt. Morrison.

The spectacular red formations of the park are sedimentary rocks of the Fountain Formation, laid down 300 million

years ago by river systems carrying debris washed from the Ancestral Rocky Mountain highlands several hundred miles to the west. About 65 million years ago, these rock layers were tilted to the position in which we see them today when the present Rocky Mountains were uplifted during a long period of intense mountain building. Later, during the Great Ice Age that began 2-3 million years ago, erosion caused by torrential streams from melting snow and ice, carved the gigantic red formations found in the park and in a few other areas along the Front Range.

These tilted red rocks catch the early spring sunshine, hold its warmth, and protect plants growing close to them from cold north-west winds to bring spring a little earlier to Red Rocks Park.

One of the most rewarding areas for flower seekers is the north-west corner of the park where there is a small public parking area. Easy trails fan out from here and wander among the formations; one trail descends to the north and meets a small intermittent stream. Beginning in late February with Oregon grape with its bright yellow clusters of small flowers and evergreen, holly-like leaves, one can find an increasing procession of wildflowers which reaches a height of spring bloom in late April and early May. Later in the summer Oregon grape will bear clusters of blue berries that can be made into excellent jelly.

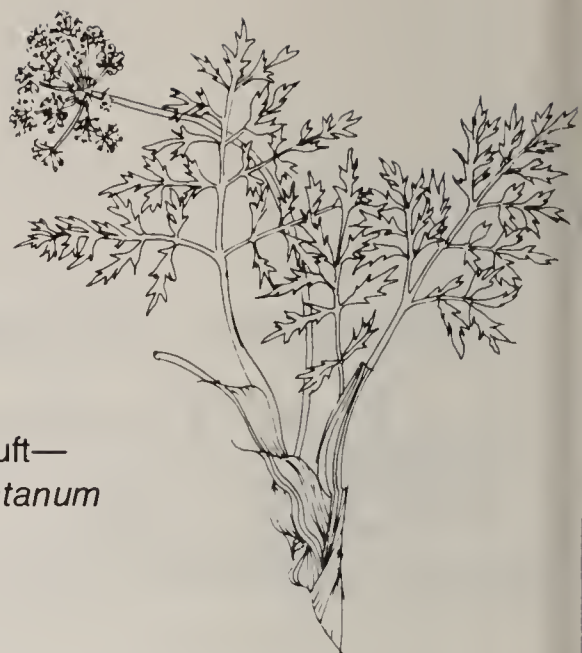
Some other flowers to watch for are spring beauties (*Claytonia rosea* Rydb.), a common spring wildflower of the

Mary Edwards, botanist and volunteer in the Kathryn Kalmbach Herbarium at Denver Botanic Gardens, leads the Plant Life field trips for the Gardens.

1. Wild plum—
Prunus americana



2. Wild candytuft—
Thlaspi montanum

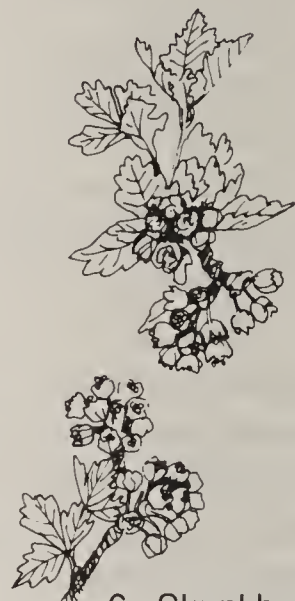


3. Salt-and-pepper—
Lomatium orientale

4. Sand lily—
Leucocrinum montanum



5. Sagebrush buttercup—
Ranunculus glaberrimus



6. Skunkbrush—
Rhus trilobata



7. Nuttall's violet—
Viola nuttallii



8. Wild allysum—
Alyssum minus

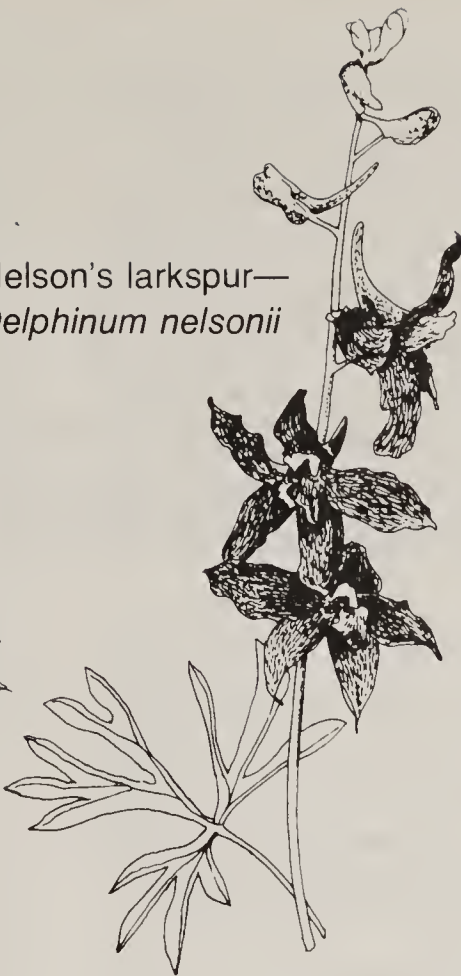


9. Spring beauty—
Claytonia rosea

10. Easter daisy—
Townsendia hookeri

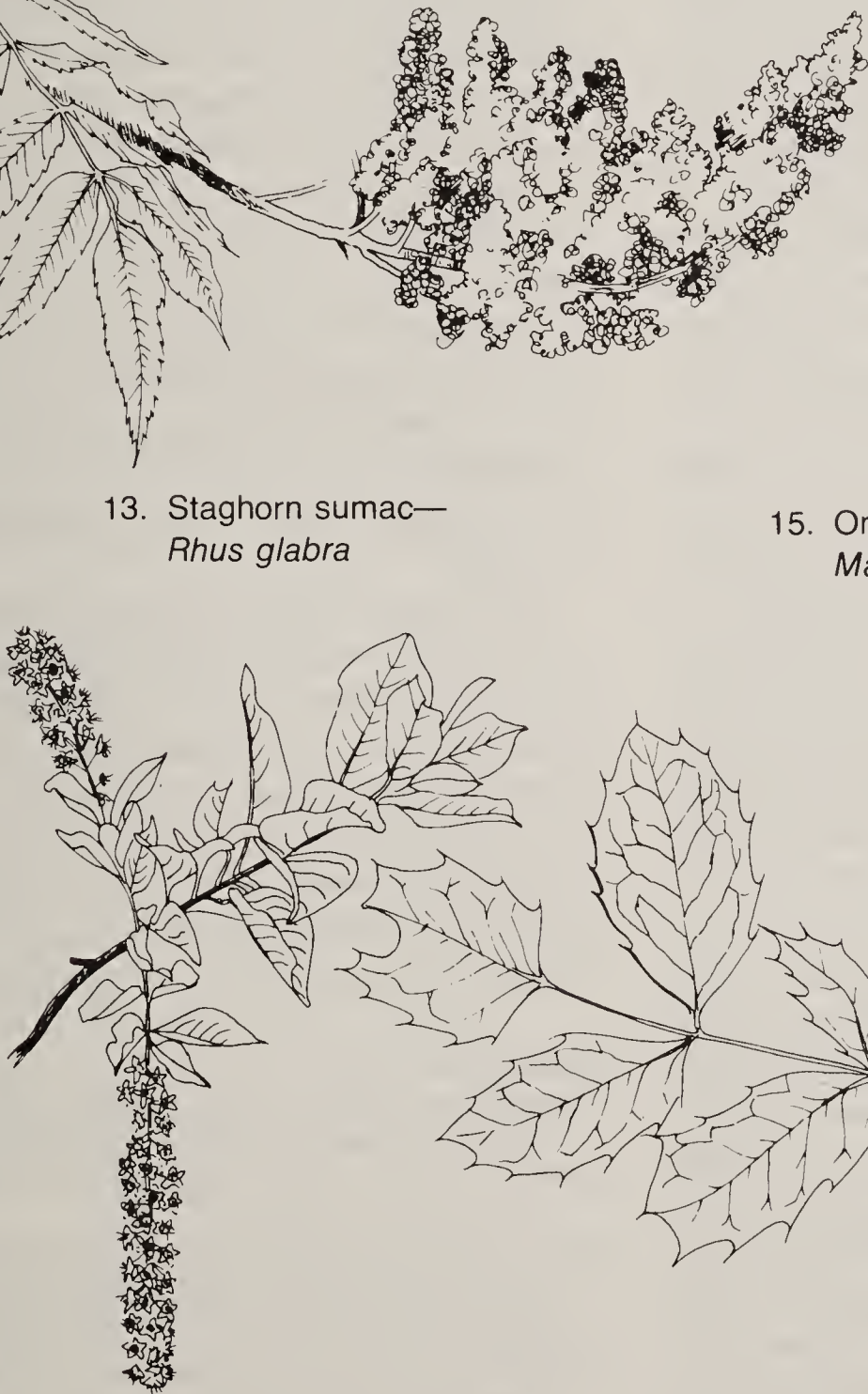


11. Nelson's larkspur—
Delphinium nelsonii



12. Mouse-ear chickweed—
Cerastium arvense

13. Staghorn sumac—
Rhus glabra



15. Oregon grape—
Mahonia repens



14. Chokecherry—
Prunus virginiana var.
melanocarpa

purslane family found in moist spots in the foothills and later higher in the mountains. It is a small, somewhat succulent plant with delicate white or pink flowers with five petals, the petals etched with darker veins. Like other members of the purslane family it has only two sepals. The tuberous corms were used as food by Indians. Cultivated moss-rose is a relative of spring beauty as is the weedy purslane.

Nuttall's violet (*Viola nuttallii* Pursh) is an early-blooming violet of the plains, mesas and foothills and is common at Red Rocks Park. Petals are yellow, usually tinged with purple or brown beneath. It is named for Thomas Nuttall, an early western botanist.

Salt-and-pepper (*Lomatium orientale* Coult. & Rose), abundant on sunny hill-sides in early spring, is one of the first wildflowers to bloom. A member of the carrot family, some of its cultivated relatives are parsley, celery and parsnip. Tiny white flowers with black anthers give it a speckled appearance, hence the common name. Sometimes it is called biscuit-root as Indians and pioneers often used the thick starchy root for food.

The cheery yellow blossoms of the little sagebrush buttercup (*Ranunculus glaberrimus* Hook.) is a welcome sight in moist places in the foothills in early spring and is very common in Red Rocks Park. A delight to find, and one of the very earliest is the Easter daisy (*Townsendia hookeri* Beaman), a low tufted or "cushion" plant of the aster family with greyish leaves and flowers with white rays.

Other early flowers growing here are wild candytuft (*Thlaspi montanum* L.), a low, small white flower belonging to the mustard family; sand lily (*Leucocrinum montanum* Nutt. ex. Gray) with clusters of grass-like leaves and numerous small white lily-like flowers. Still others are mouse-ear chickweed (*Cerastium arvense* L.) and Nelson's larkspur (*Delphinium nelsonii* Greene), named for Aven Nelson, an outstanding early Wyoming botanist.

The most abundant wildflower in the park, blanketing hill and roadside in

late April with a light yellow haze, is wild alyssum (*Alyssum minus* (L.) Rothmaler), an introduced Eurasian weed, common throughout the Denver area. This low annual plant of the mustard family has greyish, hairy leaves and tiny yellow four-petaled flowers. If you have a hand lens look for interesting star-shaped hairs on stems and leaves.

Moist temporary drainage areas between the rocks are choked with wild plum (*Prunus americana* Marsh.) thickets. These low shrubs or small trees are covered in late April before the leaves are out, with umbels of small fragrant white blossoms. Chokecherry (*Prunus virginiana* L. var. *melanocarpa* (Nels.) Sarg.) forms thickets also, but is not quite as common here and the hanging clusters of white flowers bloom a little later than wild plum. Fruit of both of these members of the rose family make fine jelly and jam, and both are an important food supply for birds and small animals. Two other common shrubs in the park are staghorn sumac (*Rhus glabra* L.) and skunkbrush or lemonade-berry (*Rhus trilobata* Nutt.), both of the sumac family and close relatives of poison ivy, though neither is poisonous. In fact, the sticky red berries of skunkbrush make quite acceptable lemonade.

Red Rocks Park is an easily accessible example of foothill vegetation found along the eastern slope of Colorado's Front Range. Only a few of the earliest blooming shrubs and wildflowers have been discussed here. Many more can be found throughout late spring and early summer. Come and explore this interesting area. But only admire—do not pick!

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KNOWING—GROWING—CONSERVING NATIVE PLANTS

When Is a Plant Native?

by William A. Weber

Recently a British botanist, D. A. Webb, published a thought-provoking essay called "What are the criteria for presuming native status?" (*Watsonia* 15:231-236, 1985). In it he shows how difficult it often is for botanists to know what is "native" to the tight little island of England and what was brought in (and this might date back to the Vikings and the Romans!). In Colorado we don't have quite as much trouble, because we don't have that long history of colonization and conquest, but we do have our aliens, and sometimes it is hard to know whether they really were brought to us in historic times or not, deliberately or accidentally.

Best to begin with a few definitions. I prefer "indigenous" to "native" (Webb says that some authors interpret "native" as synonymous with "long-established") as meaning "original to the area, not introduced." Among indigenous plants, some are "endemic"—confined to a given region; this word can be modified to "broadly" or "narrowly" depending on the size of the area occupied. Some are "disjunct"—having one area of habitation widely separated from another. "Cosmopolitan" means world-wide, but few species really are this way; people

find it just too tedious to list all of the places they occur.

Some terms for non-indigenous plants are: "adventive"—coming from elsewhere, usually accidentally; "introduced"—deliberately brought in; "escaped from cultivation"; "weed"—often used in the same context but even native plants can behave as weeds, *Helianthus annuus* (common sunflower) and *Cleome serrulata* (Rocky Mountain bee plant), for example. The word "weed" has an enormous number of different connotations; they don't concern us here. People probably get the notion from using floras that the botanist has some miraculous way of knowing whether a particular plant is indigenous or not. Unfortunately, they do not; and too often they dutifully copy what someone else has said without applying their minds to the local situation. The purpose of these pages is to extend Mr. Webb's interesting question to the Colorado scene, and to bring up some other random but interesting points about indigenous flora.

The indigenous flora of the eastern Front Range foothills is somewhat of an extension of the Black Hills flora; eastern woodland-prairie species formerly reached to the base of the Rocky Mountains along the river systems, and Rocky Mountain species occurred along the ridges as far east as western Iowa. The drying up of the Great Plains left bits and pieces of the eastern flora in cool protected gulches of the foothills. There are a number of indisputably indigenous species in this category. *Pedicularis*

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canadensis (a lousewort), *Hypoxis hirsuta* (yellow-eyed grass), *Stipa spartea* (porcupine grass), *Betula papyrifera* (paper birch), and *Sporobolus heterolepis* (prairie dropseed) are good examples. They are scattered in small populations near to extinction up and down what will soon be a completely "urban corridor."

Several indigenous plants of eastern United States, however, were discovered in such places around Boulder. *Viburnum lentago* (nannyberry), *Impatiens capensis* (jewelweed), and *Sambucus canadensis* (elderberry) are a few examples. After a lot of waffling I finally decided that these were not indigenous but introduced. Why? First, they did not occur in any other localities, but only around Boulder. The elderberry only occurred along ditches that carried runoff water from the Darwin M. Andrews nursery (he specialized in growing natives). Jewelweed also occurred only along ditches (it has later spread to other floodplains). Nannyberry grows in Bluebell Gulch, along with *Narcissus*; *Berberis vulgaris*, common barberry; *Viburnum lantana*, wayfaring tree; *Lonicera*, honeysuckle; and *Papaver orientale*, Chinese poppy. I suggested that the early settlers of Boulder, having no irrigation but wanting to grow some of their favorites, planted them in the gulch where they would not need irrigation. The occurrence of these eastern natives along with obvious introductions could be called "guilt by association." I presume I guessed right, but I may be wrong, just as the senator [J. McCarthy] was.

Many of our introductions originally were garden plants from the mining days (*Saponaria officinalis*, bouncing bet; *Papaver croceum*, Iceland poppy; *Linaria vulgaris*, butter-and-eggs; *Clematis orientale*, oriental clematis). Some of these behave themselves very well as roadside weeds. Oriental clematis probably was cultivated in Idaho Springs and spread up and down the Clear Creek Valley but nowhere else—until recently; with highway construction it has turned up in Moffat and Garfield counties. St. Johnswort, a poisonous plant that photo-

sensitizes white cattle that graze on it, may have been introduced with straw during the building of the railroad around 1918 and for many years it covered thousands of acres on Rocky Flats without showing any tendency to spread. Suddenly it has begun to spread along roads up into the mountains and is established near Glenwood Springs.

A little southern European annual *Alyssum minus* appeared in a pasture near Kiowa in 1953. In 1964 it dominated the embankments of the Boulder-Denver turnpike. Now it is all over the plains and the western slope, coloring the rights-of-way pale green in May, but not giving later-comers much competition since it withers within a few weeks. The big thistle, *Carduus nutans*, first appeared in



Saponaria officinalis—Bouncing Bet

Boulder County as a few plants in the floodplain of South Boulder Creek. Now it covers enormous tracts in pastures, fields and rights-of-way all over Colorado. There are new examples almost every year of weeds that evidently started in a small patch, sat there and patiently let natural selection bring out an ecotype perfectly adapted to the area and all of a sudden—poof! A new plague! Why are some introductions so terribly aggressive and some so tame?

Some introductions do not "take." Luckily, this seems to be true of some Mediterranean weeds imported in flower seed packets meant to "revegetate" disturbed areas. A baby's breath, a bright scarlet flax, and other strangers have turned up on the Mesa Trail near Boulder, but thus far the introductions have been unsuccessful. Revegetation so often means covering an area with something—anything—green. Why can't we Americans learn the lesson of Australia that you cannot casually introduce plant species and expect them to stay put. Australia introduced the prickly pear and then introduced the rabbit to take care of it, and then all hell broke loose. This could happen here with misguided revegetation buffs seeding our roadsides, quarries and denuded forests broadside with everything under the sun.

A gigantic species of butter-and-eggs, *Linaria dalmatica*, invaded an *Iris*-covered slope near my house, the first time I had encountered it in Colorado. Now it covers acres and acres in the Arkansas Valley near the Chalk Cliffs, and in eastern Moffat County. But strangely enough, without any attempt on anyone's part to control it, the population near my house has disappeared almost without a trace. Why? I have no idea, but it's a very interesting fact. But there seems to be a natural check on some weeds, easy come, easy go!

Introductions are not always from one continent to another nor accomplished by the hand of man. In Boulder there is a fine specimen of scarlet oak perched at the base of the first Flatiron. I do not think that Ernest Greenman, who planted



Carduus nutans—Musk Thistle

Gambel oaks around here to see if they would survive in the wild north of Denver and Evergreen, was responsible. A beautiful purple-leaved *Rosa* also has colonized the Flatiron screes. The vector is probably the Steller's jay, carrying fruit from gardens in town. A piñon pine tree about 40 years old once stood in middle Boulder Canyon, probably moved from Goodview Hill east of Boulder. Isolated trees in Rist Canyon and other places near Fort Collins probably came from seeds brought by birds from the Owl Canyon population (which, incidentally, seems to have been "introduced" by squirrels rifling an Indian trader's pack).

Then there are the tumbleweeds and other weedy plants of the desert-steppe areas of the West. While it is taken for granted that the Russian thistle is an introduction, this weed probably has been here as a native from Tertiary times. It is not the *Salsola kali* of the Atlantic seacoast but rather what Aven Nelson called *S. pestifer*. It is known under an older

name, *S. iberica* (Iberia does not mean Spain in this case, but the Caucasus!) and probably it is one of the old Tertiary Asiatic-western American things. The stickseeds, *Lappula redowskii* and its relative *L. diploloma* (or something very similar) belong to a diverse Asiatic genus. And only a few years ago the first American species of the Russian mustard genus *Stroganovia* was discovered, a clear native, in Nevada!

When was tamarisk introduced? Most people think fairly recently, but Father Escalante talks about crossing riverbottoms filled with it in his journey of 1776. There seems no doubt that it was introduced, but when and by whom—the Spanish? Or the Carthaginians who Barry Fell [Harvard author of *Saga America*] says travelled all over our area leaving their tracks in coinage and rock drawings in the times of the Punic Wars? Whichever answer is right, we have to be open-minded and careful not to accept blindly the first answers that come to mind.

One summer day I took a Russian botanist up to Geneva Basin. I had explained to him that we have no species of *Caragana* growing here outside of gardens and that its place is largely taken in America by mountain-mahogany, *Cercocarpus*. Darned if we didn't round a bend four miles north of Grant and come upon a whole colony of *Caragana aurantiaca* thriving as if it belonged there. We think this species was once planted by the Forest Service for erosion control but it is hard to locate the records. Near Creede there is a mountainside covered with buffalo-berry, *Elaeagnus commutata*, probably planted by the CCC during the depression. It's obvious, isn't it, that in order to know whether a thing is native or introduced, a whole body of history and plant geographical information has to be available to us.

Now here is something that intrigues me. In a chapter I wrote for a Swiss book on the Grand Canyon I pointed out that European tourists should always feel at home traveling by bus on the highways of our West because, since they cannot see

beyond the right-of-way, practically all of the plants they do see are ones they are familiar with in Europe. Why are the European plants, not necessarily weedy in their homelands, so aggressive here? Why are not American native species becoming equally aggressive weeds in Europe and elsewhere? A few are. Mesquite is a pest in India; *Parkinsonia* in other dry tropical areas such as the Galapagos Islands.

Adventive plants arrived in our country by ship during the 19th century, the seeds being dumped at our ports with ballast carried in the empty cargo holds. Portland, New York, and Charleston were major jumping-off places. After acclimatization, the weeds simply followed the railroads west or east, eventually arriving in Colorado. Jim Hill mustard commemorates one of the railroad magnates of the day. There are some ballast sites in Europe but not many American plants seem to have spread from them. However, plant collecting in Sweden, for example, has been so intensive over the centuries that the precise direction and speed of the spread of weeds is comparatively well known and documented.

Alien plants cannot survive in a new area unless they are suited to the climate. The distribution of aliens in our country mirrors the climate of the areas in which they were native. Therefore, each region of the United States has a special adventive flora. California has species from the Mediterranean shores. Colorado seems to have a southeast Europe-middle East flavor. Salt Lake City has still another species spectrum not found in Colorado. In other words, the kinds of introduced plants that survive in an area should indicate precisely what parts of the world have the most similar climates. Such information cannot be gotten as cheaply or quickly by the most sophisticated instrumentation available to science.

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An Account of the Sempervivum Group.

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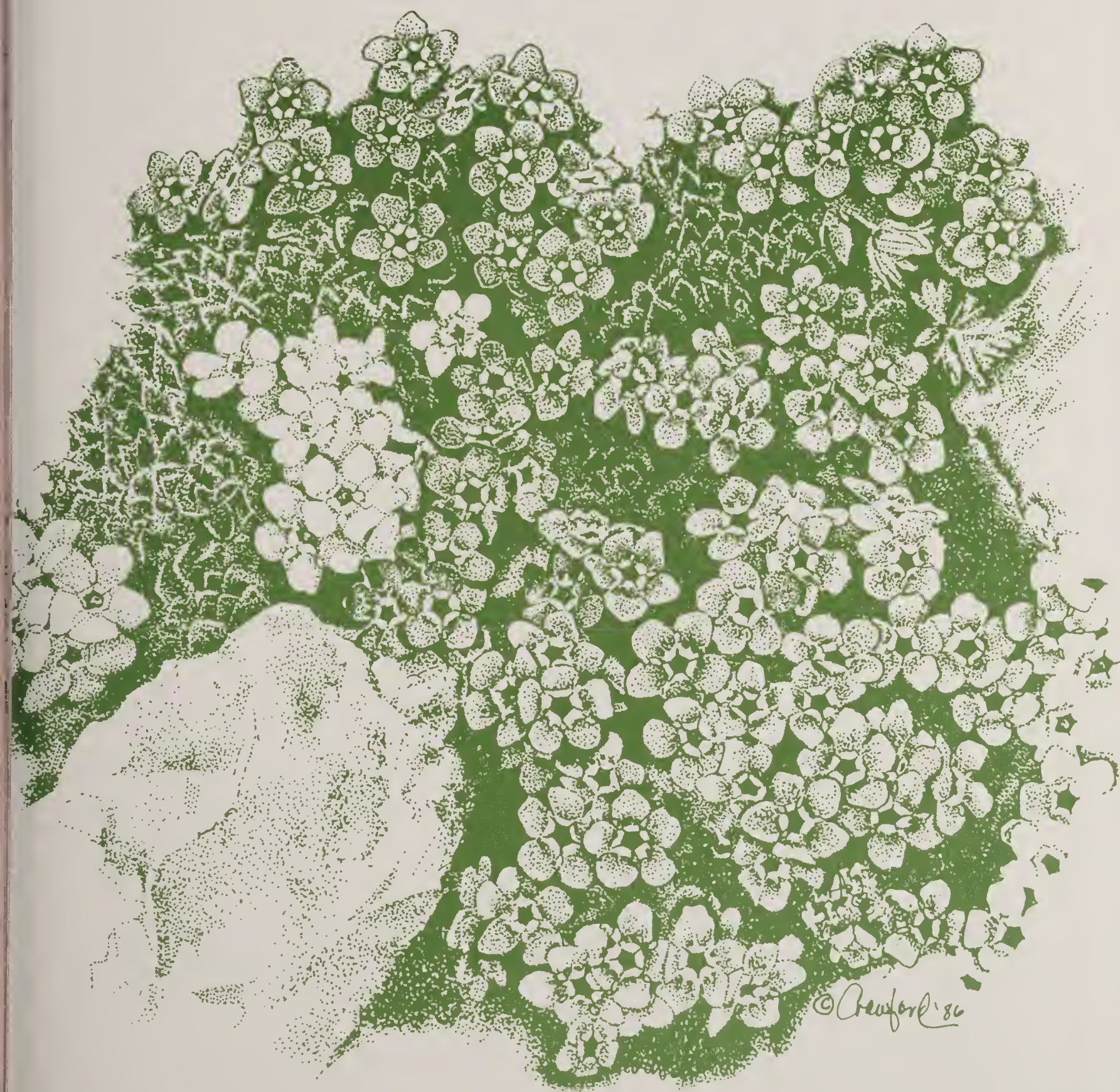


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The Cover

Alpine forget-me-nots

Carolyn Crawford

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The Green Thumb

Summer 1986

Velma A. Richards
Editor

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Natural Gardening in Colorado

by Panayoti Kelaidis

Natural gardening has a long and rich history. In the Orient many traditional gardens were little more than rocky outcrops where a body of water and a view combined to create the "spirit of place." A simple path, a shrine and a name were all that were needed to convert the place into a garden. From the time of the Renaissance great European gardeners sought out wild flowers not only for their medicinal applications but also for their intrinsic beauty. By the Victorian era leading gardeners of Britain advocated the use of wild plants grown in simple groupings modeled on nature rather than geometric principles.

Horticultural pioneers in Colorado

Eminent Colorado horticulturists stood firmly in this tradition. S.R. DeBoer planted the many boulevards and parks of Denver with naturalistic groves of trees. He also designed ambitious rock gardens at the Sunken Gardens in front of West High School, at City Park and in various private residences precisely for growing native plants. M. Walter Pesian lectured and wrote extensively on natural garden design and incorporated rocks and natives in many gardens and roadside parks. With missionary zeal, George Kelly promoted the use of native plants in home and commercial landscapes.

Darwin M. Andrew's Rockmont Nursery in Boulder and Kathleen Marriage's Upton Gardens in Colorado Springs gained international prominence for their extensive catalogs including many Rocky Mountain trees, shrubs and wild flowers. They sold seeds as well as plants mail order. Both proprietors not only advocated the use of wild flowers and native plants in gardens but also lectured and published widely on their culture and use. The careers of these remarkable pioneers spanned much of the first half of this century.

Dichotomy in design

Meanwhile, the Front Range region continued to be platted, planned and built. The architects and engineers responsible for most of this development were orderly people who found it convenient to coordinate their designs with the neat rectilinear township and range grids that invisibly order the human superstructure west of the Appalachians. A dichotomy has resulted from this situation: homeowners and landscape professionals alike proclaim their love for the Rocky Mountain landscape and wild plants. But practically everyone gardens on small, geometrical city lots that are far removed—literally and figuratively—from the Rockies and the untrammelled shortgrass prairies of the West. The challenge for the natural gardener, then, is to create the illusion of a place in nature in the cramped and noisy confines of our cities.

Panayoti Kelaidis is curator of the Rock Alpine Garden at Denver Botanic Gardens.

How can this be done? Surely there is no better way of finding out than to visit some of the local gardens that have been successful in creating this illusion. All of these gardens have been created by gardeners who have a deep understanding of plants, their origins and associations. Although these gardens contain tremendous collections of interesting and often rare plants, their creators are not just plant collectors. Their ultimate goal is to grow plants artistically and harmoniously. Though scientific in the study of his materials, the plantsman is nevertheless an artist in combining them.

The plantsman's garden rarely seeks to create a single, uniform environment suiting only one kind of plant. Instead, he will take advantage of different conditions within the garden: shady areas become woodland gardens for shade-loving plants; south exposures often have cacti and desert plants. Microclimate becomes an organizing principle.

One feature that unifies all of these gardens is the use of rock work. Local plantsmen strive to grow plants from the neighboring high plains to our high mountains that need the superior drainage provided by crevices in rock gardens. Many alpine plants are so small they would be lost to view unless raised closer to eye level by a rock garden.

Other features unify these gardens: they make maximum use of outdoor space for informal entertaining. Certain native plants such as curleaf mountain mahogany and pussytoes appear again and again. Natives suited to a specific microhabitat are combined with plants from other regions of the world with similar environments. Local dryland species are often planted with exotic, drought tolerant plants to minimize the need for irrigation.

Plants are chosen for various attributes—not flower color alone. These are gardens for every season: mats of ground covers are colorful at all times, and a wealth of broadleaf evergreens and conifers as well as deciduous trees and shrubs with ornamental bark make these gardens interesting even in winter.

Plantsmen are forever experimenting. Their gardens are beautiful, but they are laboratories as well. In these gardens a new tradition of truly indigenous horticulture is being forged.

The Maslin garden

Few gardens have exerted a greater influence on Rocky Mountain gardening than this small, urban garden on "The Hill" in Boulder. From here, thousands of plants have found a home in other local gardens, and subsequently into nurseries throughout the region. Over the years, numerous visitors have marvelled at the subtle combination of plants in this garden. It was designed and built over a period of 30 years by T. Paul Maslin, a professor of zoology at the University of Colorado at Boulder. The garden is living testament to his wisdom in choice and placing of plants.

This garden represents a fascinating blend of oriental and European styles, for Dr. Maslin was deeply interested in both traditions. He had constructed six gardens before beginning his last garden in the early fifties. By this time he had firm notions of what sort of things he liked or didn't like in a garden.

A garden must be naturalistic. This is reflected in the broad, informal curves and bending lines of lawn and flower beds that soften and mask the lines in the modernistic home. In excavating for the foundations of the house, many giant red sandstone boulders were uncovered and rolled to the periphery of the property to be used later in the garden design. Once the foundation was dug, the entire lot was carefully contoured and terraced. Where there had been a gradually sloping piece of ground, there were now several terraces divided by paths, lawn, rock work and eventually by trees so that the garden could never be seen in its entirety from one place. Each terrace, or level, has its own axis and focal points; the garden actually consists of numerous smaller gardens that are self-contained and yet relate to the whole.

Over the years, many thousands of plants have been grown here, bringing together plants from around the world that flourish in a habitat common to them. Let us concentrate on some of the several hundred woody plants that grow so harmoniously on this city lot.

Aside from a narrow strip of grass along the parking, turf is used functionally and sparingly in artistically sculptured curves to provide access to the various rock outcrops and borders. The front yard has gradually evolved into a shrub border with perennials serving a subsidiary role. A golden chain tree, *Laburnum anagyroides*, stands in the shade of a grove of ponderosa pines. A large bed of robust rhododendrons—*Rhododendron* 'Scarlet Wonder' is particularly floriferous—thrive in this shady micro-

climate where they are never scorched in summer or winter. Across the driveway, a lacebark pine, *Pinus bungeana*, now towers some 30 feet with more rhododendrons and several species of *Daphne* forming a thicket at its base.

Subshrubby perennials such as misty blue Russian sage, *Perovskia abrotanum*, and scarlet, fuchsia-like Arizona zauschneria, *Zauschneria arizonica*, riot with color in the late summer months. Cornish heath, *Erica vagans*, blooms prodigally every autumn—possibly the only specimen for a thousand miles in any direction.

A saucer magnolia, *Magnolia x soulangiana*, shades the entryway to the house, where many unusual dwarf conifers form a unique collection. An 8-foot threadleaf false cypress, *Chamaecyparis pisifera* 'Fi-





Dwarf conifers screen the steps leading to the Maslin residence.



Lawn provides a functional path through the rock outcrops.



Rock and water provide dramatic focus in center of backyard.

lifera,' grows a few feet from its more dwarfed, golden-needled cultivar called 'Goldie.' Both have been pruned sparingly to enhance their oriental flavor. *Daphne x burkwoodii* 'Somerset' has grown for many years in the shade of the magnolia forming a gnarled, 5-foot mound of fragrant bloom both spring and fall. Nearby, a spicy-flowered viburnum, *Viburnum x carlcephalum*, perfumes the air in midspring. Growing here are other unusual conifers: a 7-foot Alberta spruce, *Picea glauca* 'Albertina Conica,' and several forms of Norway spruce, *Picea abies*. An arborvitae, *Thuja occidentalis* 'Rheingold,' makes a striking, bronzy contrast to the other, greener conifers and shrubs. Dwarf balsam fir, *Abies balsamea* 'Nana,' and a tiny form of yew, *Taxus x cuspidata* 'Nana,' complete this collection of miniatures. They are all woven together with a sea of hellebores, aroids, heathers and bulbs which rise through groundcovers both spring and fall to make a dramatic picture.

Junipers in the Maslin garden are all rare and seldom seen in gardens. Vase-shaped Himalayan junipers, *Juniperus squamata* 'Meyeri,' have been pruned to show off their peeling silver bark. Two large native "cedars" were planted together for the comparison: one-seeded juniper, *Juniperus monosperma*, with several trunks from the eastern slope of the Rockies and a bluer leaved, single stemmed Utah juniper, *Juniperus osteosperma*, from the western slope. The other unusual juniper, *Juniperus communis* 'Echiniformis,' is barely a foot tall after several decades of growth. A dwarf manzanita, *Arctostaphylos nevadensis* var. *coloradoensis*, now spreads beneath the Himalayan junipers.

In early spring the view through a carport into the back yard frames a large star magnolia *Magnolia x loebneri*, a 30-foot spire of giant, fragrant white blossoms. Numerous unusual trees and shrubs around the periphery of the back yard form a backdrop for the extensive rock gardens that contain sweeps of jewel-like bulbs, herbaceous groundcovers and dwarf shrubs. A few plants here



Rustic stone wall and gateway give a country feeling to a city garden.

and there demand attention: dwarf brooms, *Cytisus decumbens*, etc., and heathers (many cultivars of *Erica herbacea*) are used liberally, with even more azaleas, rhododendrons and dwarf conifers. In spring species of *Primula*, *Androsace*, and *Gentian* are especially vivid.

Across the grassy path an 8-ton boulder, discovered and left in place during terracing operations, forms a study vantage point to view pond and water gardens. A partly shaded rock garden surrounds a pool and bog garden overhung with a dramatic weeping Hopa crab, *Malus* sp., and pin oak, *Quercus palustris*. The pool is filled with water lilies and the boggy garden has a variety of unusual plants including giant coltsfoot, *Petasites japonicus*, with leaves that can grow to a foot and a half in width.

To the north of the pin oak a steep, rocky bank harbors a wealth of woodland plants: double-flowered bloodroot, *Sanguinaria canadensis* 'Multiplex,' hepaticas, *Hepatica americana*, jack-in-the-pulpits, *Arisaema atrorubens*, and many ferns including the unusual hartstongue, *Phyllitis scolopendrium*.

A stony path bordered by several

species of anemone, epimedium, trillium and woodland bulbs leads to the highest, terraced level of the Maslin garden. Here is a more formal garden with a perennial border stretching some 30 feet along a neatly mortared stone wall built over several years by Maslin himself. The wall is now obscured by numerous unusual vines, including grapes which form an arbor over yet another patio, the third in this most inviting garden.

This western portion of the garden includes such surprising and unusual plants as a broad-leaved, variegated, evergreen lily turf from Japan, *Liriope muscari* 'Variegata,' and a completely hardy, deciduous agapanthus, *Agapanthus campanulatus*, that produces large clusters of vivid blue flowers in late summer.

The Maslin garden is never the same from day to day. Always some new flower is emerging, some half forgotten shrub suddenly gains a new lease on life and bursts into spectacular bloom. There is no way to see the garden in one view—it has been built to linger through, with every turn revealing some new treasure of bloom, foliage and form.

A Colorado garden

About the time Paul Maslin was busily arranging his rock gardens in Boulder, J.V. and Bernice Petersen were building their present Littleton home on a steep hillside with a dramatic mountain view. Their interest in horticulture was fanned into full-fledged enthusiasm while attending landscaping classes taught by George Kelly, then director of Colorado Forestry and Horticulture Association. George and Sue Kelly, whose Cottonwood Garden Shop was a magnet for Colorado plantsmen, assured them that the steep slope would be no problem: rock walls and rock gardens would blend their home into the hillside.

Three years and 68 truckloads of lichened rock and flagstones later the job was done. Since the garden primarily faces southwest, the Petersens sought to minimize watering and intensive maintenance. Buoyed by the Kellys' encouragement and willingness to share their horticultural knowledge, they chose to use native plants that harmonized with the natural landscape.

Today the garden has matured into what the Petersens call a Colorado garden featuring many native plants com-

bined with appropriate exotics. Visitors approaching the garden from the west are greeted by a bevy of native shrubs: an immense squaw apple, *Peraphyllum ramosissimum*, a sea of holly grape, *Mahonia repens*, mountain mahogany, *Cercocarpus montanus*, Apache plume, *Falugia paradoxa*, ninebark, *Physocarpus monogynus*, and yuccas, *Y. glauca*, all growing effortlessly without added water.

A giant white fir, *Abies concolor*, and a superbly sited curleaf mountain mahogany, *Cercocarpus ledifolius*, help screen the garden from the street to the west. Many plants throughout the garden, such as the squaw apple, are results of experimentation with growing natives by early plantsmen including Kelly, Bill Lucking and Harry Swift. Such plants are often the only remaining evidence of these early tests: a living testament to a great era of study and exploration of western horticulture.

Retaining walls adjoining the west wall of the house have matured into a tapestry of rock and plant that needs little water or attention. The crevices are neatly filled with sempervivums and



A squaw apple rises from a sea of Oregon grape with white fir behind. Across the path evergreen mountain mahogany screens house from the west.



Perennials cascade over a retaining wall.

other rock plants. For many years Mrs. Petersen was chairman of the rock garden booth at Denver Botanic Gardens annual spring plant sale, and her garden has served as a source of cuttings and seed for that sale since its inception.

A rugged old plant of silver sage, *Salvia argentea*, clings to a bank along a path. For 20 years it has lingered, bloomed and finally seeded. It came from a plant sale where several dozen seedlings had been potted into milk cartons to accommodate the deep roots. Today local nurseries grow and sell this spectacular foliage plant with its silvery fur-coated leaves. All of these plants can trace their pedigree to this ancient specimen at the Petersens.

A large flagstone patio extends along the south side of the house. The crevices and much of the flagstone are covered with tiny rosettes of pussytoes, *Antennaria parvifolia*, descended from a single

clump brought from the mountains. Each year seeds are gathered here to supply the needs of a large local wholesale nursery. A low retaining wall along this patio is filled with many more rock garden gems including a yard-wide lacy mat of Caucasian sage, *Artemisia caucasica*.

A sweep of lawn separates the patio from perennials bordering the south side of the property. Here are plants selected for character and texture that flourish and bloom at many times of the year. Offered only occasionally by local nurseries, gasplant, *Dictamnus albus*, with its spires of intricate pink or white flowers and starry seedpods is treasured for its delicate lemon scent.

Just as vegetable gardeners pride themselves on heirloom crops, plantmen pride themselves on precious plants that grow too slowly, or simply have never captured the widest market. *Phlox* 'Snowcap,' hybridized by D.M. Andrews



of Boulder, came to the Petersens from the nursery of Frank Richards in Fort Collins—another great Colorado plantsman.

Double pink coralbells, *Heuchera sanguinea*, came to the garden as a single cutting in late August from the garden of Leah Brown, a long-time volunteer at DBG; two years later it had grown large enough to be divided into 35 husky plants. Throughout the summer this versatile southwestern wild flower makes a subtle but delightful coral edging in the perennial border. Other gems include a variety of ornamental onions and several peonies—many of them heirloom plants now rarely available in commerce. Large clumps of fernleaf peony, *Paeonia tenuifolia*, have been shared with many friends including DBG, but it never seems to grow quite fast enough to appear in local nurseries.

A hedge of trees and shrubs forms a background for the perennial garden. Here are some large New Mexican privets, *Forestiera neomexicana*, and giant specimens of scrub oak, *Quercus gambelii*, purchased only a few years ago, it seems, from Harry Swift's Western Evergreens for only 50 cents apiece. Other natives here are thimbleberry,

Rubus deliciosus, and silverberry, *Shepherdia argentea*. At the southwest corner providing welcome shade in summer months is a huge burr oak, *Quercus macrocarpa*, grown from a seedling from a gardening friend. A magnificent white pine, *Pinus strobus*, provides a screen for an unsightly utility pole.

Red-berried cotoneasters, grown from cuttings, ranging from rock hugging *Cotoneaster adpressa* and *C. apiculata* to *C. soongorica*, a small tree, can be found throughout the garden. A large Ohio buckeye, *Aesculus glabra*, spectacular in bloom or golden fall color screens the neighbor's house. Evicted from its home of 17 years at Kellys' nursery to make room for potted roses, the tree was moved bare root almost 30 years ago to the Petersen garden where it thrives today.

Many unusual dwarf perennials and alpiners gradually give way to a semi-formal garden on the northeast corner of the lot. A fan-shaped espalier of Meteor cherry graces the formal entryway. A tangle of two species of *Campanula* (funnel-flowered *C. portenschlagiana* and starry *C. garganica*) blooms for a long period in spring and early summer, with mats of evergreen foliage providing color the rest of the year. These trace their



From a close-up view mature colonies of succulents create intricate patterns.



A stone path winds effortlessly through the rock garden.



Perennials, conifers and succulents combined for year round color.

pedigree to Kelly, and persist in cultivation locally only because the Petersens sought local growers to propagate them for the Botanic Gardens sales.

For much of the summer, hostas, bergenias and ferns provide a fresh green ground cover for this cooler exposure. A hedge of wayfaring trees, *Viburnum lantana*, screens the street to the north, and other spicy viburnums flank the doorway.

Ever experimenting, the Petersens have replaced part of their water-intensive lawn with buffalo grass, forming a thick even turf overlooking the rock wall back at the west end of the property.

This is a garden where plants are so carefully placed and cared for that everything seems to be just where it should be. Each season, something new comes into bloom or fruit. This is truly a place to find the very best plants for local gardens. The

Petersen garden is indeed a quintessential, and ideal Colorado garden.

To be continued in *The Green Thumb*, Autumn 1986. Featured there will be Allan and Mary Taylor's *Modular Garden*, Bill and Sandra Synder's *Garden with a View*, and Robert and Anette Heapes' *Country Garden*. — Editor

COLORADO NATIVES

Design Considerations and Propagation Techniques

by Anne Wollerman Carson and Ron Arpin

Natives and native gardens have been increasing in popularity in recent years. The reasons are many. Some gardeners want to experiment, to satisfy a curious or adventuresome nature; others look at natives as a way to lower maintenance, as they often require less care and fit an informal, less frequent maintenance schedule. Still others see natives as the obvious garden choice to decrease water bills. Then, there are those gardeners who live on or near preserved natural environments who want to plant natives in order to blend with their surroundings.

The intention of this article is to supply information regarding design considerations and use of natives in the landscape and, once the decision of which plants to use is made, how to propagate and grow your own. Being able to grow native plant material for one's own garden is challenging and satisfying. It also provides the gardener with more choices of natives that can be used in landscaping. There are times when the "just right" plant is not available at retail garden centers.

Design considerations

Most influential in determining the selection of native plants for your garden

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is location; where you want to put natives will determine, in many cases, which plants may be used. Or, if you know the plants you want in your landscape, then choosing the right location is crucial to success.

A second important consideration is soil, or, more to the point, how water moves through the soil. If the soil is clayey, it will hold more water. This is tolerable for plants that like wet conditions but detrimental to natives that thrive in dry soils. In order to grow these species successfully, clay soils need to be amended with organic matter. The resulting soil mix should allow water to move in and out of the soil easily. Be aware, though, that increased organic matter may cause plants adapted to sparse conditions to grow larger and be "floppier" than their "cousins" in the wild. The ideal growing medium would duplicate the soil of the plains, foothills or mountains where a particular plant grows natively. Soil and water are also important factors in propagating and will be discussed later in more detail.

Is your spot sunny, shady, windy, protected? Is the soil dry, moist, soggy, loamy, clay, rocky? Or, do you want to use mountain ninebark, *Physocarpus monogynus*, apache plume, *Fallugia paradoxa*, pasque flower, *Pulsatilla patens*, pus-sytoes, *Antennaria* sp.? Remember that careful understanding of microclimates (water, soil, sun and wind exposure) will increase the success of your native garden.



Native shrubs and perennials combined with buffalo grass in a low-maintenance garden.

Let's look specifically at some possible planting sites and landscape needs in gardens and explore which native plants could be grown in these places.

Have you an area with a slight depression, not where water stands for any length of time but that is always moist; where water or snow melt collects? Envision a copse of native trees or a grouping of moisture loving shrubs. Although to some the term native may be synonymous with dry, it is not necessarily so. Our mountains and foothills contain many moist pockets filled with plants. One of the best ways to determine what plants to use is by observation of the natural arrangements. Go to the hills and mountains and plains and look. Observe which plants grow together or grow in similar areas. If a grove of trees would suit your yard, what other plants will be compatible? Some of the moisture loving trees are: native birch, *Betula fontinalis*; thin leaf alder, *Alnus tenuifolia*; gambel oak, *Quercus gambelii*; and pin cherry, *Prunus pensylvanica*. Some of these species also grow in drier soils and are then smaller and more shrublike.

Some native shrub choices for moist soils include mountain mock orange, *Jamesia americana*, native red-berried

elder, *Sambucus racemosa* ssp. *pubens*, russet buffaloberry, *Shepherdia canadensis*, western mountain ash, *Sorbus scopulina*, redbud dogwood, *Cornus stolonifera*, bluestem willow, *Salix irrorata*, and twinberry honeysuckle, *Lonicera involucrata*.

Many ground covers and perennials prefer moist soils. Among them are: cranesbill, *Geranium* spp.; aspen daisy, *Erigeron speciosus*; pasque flower, *Pulsatilla patens*; wild strawberry, *Fragaria americana*; columbine, *Aquilegia* spp.; and harebell, *Campanula rotundifolia*.

One design consideration to remember when selecting natives for a garden: use a large grouping of a few species rather than one or two of several different kinds. The latter will be too busy and plants will be lost in the chaos. Although you may see examples of one of each when you observe in the wild, nature can get away with this in her wide open spaces. In the confines of our urban/suburban lots, more of one kind and fewer kinds usually result in better visual impact.

Do you need hedging or screening? Several native shrubs do well in an exposed, sunny location. Mountain mahogany, *Cercocarpus montanus*, is an excellent choice. Other possibilities in-



Pussytoes soften a flagstone patio.



Many native perennials in low-maintenance desert garden.

clude yellow flowering currant, *Ribes aureum*, curlleaf mountain mahogany, *Cercocarpus ledifolius*, and wild plum, *Prunus americana*. Another design consideration: Plan ample growing space for a mature plant, especially if low maintenance is the goal. The size of a mature plant seen in the wild may have been affected by browsing, so check reference books to learn the likely size of the plant considered. Also, the plant in your yard may get more water (and therefore grow bigger) if you have heavy clay soils. This soil type holds water for a longer period of time than the decomposed granite soils of the plains, foothills and mountains.

Is a hot, dry slope the site for your native garden? Consider some of the native pines: ponderosa pine, *Pinus ponderosa*; limber pine, *P. flexilis*; piñon pine, *P. cembroides edulis*; or shrubs: three-leaf sumac, *Rhus trilobata*; wild plum, *Prunus americana*; Rocky Mountain smooth sumac, *Rhus glabra cismontana*; Apache plume, *Fallugia paradoxa*; rabbitbrush, *Chrysothamnus nauseosus*; or Adam's needle yucca, *Yucca glauca*. Ground covers and perennials for a dry area include fireweed, *Epilobium angustifolium*, blanket flower, *Gaillardia aristata*, beard tongue, *Penstemon* spp., sulphur flower, *Eriogonum umbellatum*, and Lambert's locoweed, *Oxytropis lambertii*.

Do you have a flagstone or concrete block patio that needs a soft touch? Try one of the following ground covers between the stones or in a cluster along the side: pussytoes, *Antennaria* sp.; Lambert's locoweed, *Oxytropis lambertii*; sulphur flower, *Eriogonum umbellatum*; blue flax, *Linum lewisii*; or dwarf goldenrod, *Solidago decumbens*.

Many native plants have unique beauty that can be most appreciated at close range. You may want to place a native garden near a "people area" of your yard, where the plants will be easily seen. For this situation consider the shrub, bush rock spirea, *Holodiscus dumosus*, a fragrant, white-blossomed plant with either flowers or seed heads most of the year. The beautiful flowers of *Yucca glauca* merit close-up inspection. Some of

the smaller native perennials are well-placed in a small garden. Cut-leaf daisy, *Erigeron compositus*, blue-eyed grass, *Sisyrinchium montanum*, dwarf columbine, *Aquilegia saximontana*, and paper flower, *Zinnia grandiflora*, are possibilities.

Propagation techniques

Generally propagating your own plants can be an easy process if you know and follow a few precautions. A seeding mix that has a high percentage of perlite or sand is preferred. Besides providing a high amount of oxygen for the roots, the mix crumbles easily, minimizing root damage when seedlings are pricked-off. This makes the difference between having little success and being successful with plants that are sensitive to transplanting. There is no one correct soil mix. Choose and mix the soil components according to your cultural management style. Are you a "wet grower"? Are you a diligent and careful waterer or do you water everything the same? The answers to these questions should determine your soil mix.

When sowing seed, the accepted rule is to cover seeds to a depth equal to twice their diameter. For very fine seed no growing medium is placed over the seed. Fine seed that is not covered includes anything the size of petunia seed or smaller. After the seed has been sown and covered, if necessary, seedflats should be misted thoroughly and kept moist until transplanting. Seedlings can be transplanted when the first set of true leaves emerges.

For brevity, a chart has been prepared to organize information for propagating from seed. Following is an explanation of the group rating system used in this chart. Special exceptions are mentioned when necessary.

Group One: This group includes the plants simplest to grow and care for. They germinate with no pretreatments and can be transplanted easily. Sow the seed on a seedflat, cover the seed with the appropriate amount of mix, water and when

the first set of true leaves appears, prick-off into the desired container. Plants belonging in this group but needing some extra care are: *Betula fontinalis*, *Fallugia paradoxa*, *Fragaria americana*, *Jamesia americana*, *Salix irrorata*, *Sisyrinchium montanum*, *Yucca glauca* and *Pinus* species. *Betula fontinalis* should be covered only lightly with seeding mix because light is essential for germination. (After misting, most of the seed should still be visible.) Be careful when transplanting *Fallugia paradoxa*; too much damage to the root system will cause high losses. *Fragaria americana* can be grown from runners or seed. *Jamesia americana* does not transplant well, so be careful with the root system. Since it does not tolerate wetness after transplanting, water thoroughly, then water only as necessary. *Salix irrorata* can be propagated easily from hardwood winter cuttings. No hormone is necessary to enhance rooting. *Sisyrinchium montanum* is propagated by division. *Yucca glauca* seed must be soaked in water that is between 110° and 115° F for 24 hours and then sown. All *Pinus* species seedlings require limited water. After transplanting, water thoroughly, and then only as necessary.

Group Two: This entire group needs cold treatments of varying length to accomplish germination. Any seed larger than 1/16 inch in diameter will require soil mixed with the seed during cold treatment. The soil mix acts as a water reservoir. Smaller seeds exhibit water holding characteristics similar to soil particles, so soil can be eliminated. Food freezer bags work well for this procedure. The appropriate amount of seed is placed in the bag, seeding medium is added if necessary and mixed with the seed, and water is added to moisten the mixture. Add only enough water, as an excess amount will suffocate the seed. The cold treatment can be performed in either the food or the freezer compartment of a refrigerator depending upon the temperatures needed. Once seed pretreatment is complete, seed can be sown and transplanted when ready. Special mention should be made of all *Aqui-*



Native manzanitas and wild flowers create a low-water requirement area.

legia and *Cercocarpus* species, *Holodiscus dumosus*, *Lonicera involucrata*, *Pentstemon strictus*, *Physocarpus monogynus*, *Rhus trilobata* and *Rhus glabra cismontana*. Care should be taken when transplanting these to minimize root damage. When pricking-off seedlings, be careful to take as much of the root system as possible; this will lessen transplant losses. Water should be monitored carefully on all the above species, for they do not tolerate wet feet. Water thoroughly after transplanting and from then on, only as necessary. There are two exceptions to the water regimen: the *Aquilegia* species and *Lonicera involucrata* should be kept moist. Both *Rhus trilobata* and *Rhus glabra cismontana* need careful handling during transplanting. Before cold treatment, *Rhus glabra cismontana* must be scarified in concentrated sulphuric acid for 60 to 90 minutes.

Group Three: This group is the most difficult to transplant and the most demanding of the cultural conditions in which they will thrive. Care must be taken when transplanting or losses will be very high. Again, be very careful to take as much of the root system as possible when pricking seedlings from seedflats. These species also will not tolerate wet feet. Water them in thoroughly after transplanting and from then on,

water on demand only. With good care, losses will be few. Special mention needs to be made for two species: *Campanula rotundifolia* is sensitive to transplanting and prefers a moist environment. For *Eriogonum umbellatum* some references recommend a 30-day cold treatment to improve germination; however, we have never used a cold treatment.

Group Four: Little is known from personal experience about propagating and growing this group. *Cornus stolonifera* grown from seed needs a cold treatment for 60 to 90 days. Transplanting should not be difficult nor would cultural conditions be a problem. Since it naturally grows along streams, frequent watering should be provided. *Cornus stolonifera* 'Baileyi' is a commercially grown cultivar that roots easily from softwood cuttings taken from May 15 to July 15 depending on local climatic conditions. It may be worthwhile to experiment with rooting *Cornus stolonifera* cuttings. To germinate *Sorbus scopulina* a cold treatment of 60 to 150 days is suggested in the manual, *Seeds of Woody Plants of the United States*. In Colorado, *Sorbus scopulina* can be found growing in protected moist areas with partial shade. Further experimentation is necessary to determine ease of transplanting and essential growing conditions.

For descriptive information about the plants mentioned in this article, read *A Guide to the Woody Plants of Colorado* by George Kelly and *Meet the Natives* by M. Walter Pesman. More details regarding propagation of the woody plants men-

tioned can be found in *Seeds of Woody Plants in the United States*, Agriculture Handbook number 450, edited and published by the Forest Service, U.S. Department of Agriculture.

Conditions for Propagation from Seed

	Group Rating	Duration of Cold Treat. (days)	Temp. of Cold Treat. (° F)
<i>Alnus tenuifolia</i>	2	120-150	36-38
<i>Anemone patens</i>	3	none	
<i>Antennaria</i> spp.	3	none	
<i>Aquilegia caerulea</i> *	2	7	0-15
<i>Aquilegia saximontana</i>	2	7	0-15
<i>Betula fontinalis</i>	1	none	
<i>Campanula rotundifolia</i>	3	none	
<i>Cercocarpus ledifolius</i>	2	90	36-38
<i>Cercocarpus montanus</i>	2	90	36-38
<i>Chrysothamnus nauseosus</i>	1	none	
<i>Cornus stolonifera</i>	4	60-90	36-38
<i>Epilobium angustifolium</i>	1	none	
<i>Erigeron compositus</i>	1	none	
<i>Erigeron speciosus</i>	1	none	
<i>Eriogonum umbellatum</i>	3	none	
<i>Fallugia paradoxa</i>	1	none	
<i>Fragaria americana</i>	1	none	
<i>Gaillardia aristata</i>	1	none	
<i>Geranium</i> spp.	1	none	
<i>Holodiscus dumosus</i>	2	60-90	36-38
<i>Jamesia americana</i>	1	none	
<i>Linum lewisii</i>	1	none	
<i>Lonicera involucrata</i>	2	store seed	36-38
<i>Oxytropis lambertii</i>	3	none	
<i>Penstemon strictus</i>	2	30	36-38
<i>Physocarpus monogynus</i>	2	60	36-38
<i>Pinus edulis</i>	1	none	
<i>Pinus flexilis</i>	1	none	
<i>Pinus ponderosa</i>	1	none	
<i>Prunus americana</i>	2	120	36-38
<i>Prunus pensylvanica</i>	2	150	36-38
<i>Quercus gambelii</i>	1	none	
<i>Rhus glabra cismontana</i>	2	90	36-38
<i>Rhus trilobata</i>	2	90	36-38
<i>Ribes aureum</i>	2	60-90	36-38
<i>Salix irrorata</i>	1	none	
<i>Sambucus racemosa pubens</i>	2	120	36-38
<i>Shepherdia canadensis</i>	2	90	36-38
<i>Sisyrinchium montanum</i>	1	none	
<i>Solidago decumbens</i>	1	none	
<i>Sorbus scopulina</i>	4	60-150	36-38
<i>Yucca glauca</i>	1	none	
<i>Zinnia grandiflora</i>	1	none	

**Aquilegia* species can also be cold treated for 30 days at 36° - 38° F.

Rocky Mountain Alpines: A New Guide to Native Treasures

by Gwen Kelaidis

Alpine enthusiasts from around the world will hold a conference this summer in Boulder to study and see the plants we take so much for granted, from Easter daisy, *Townsendia*, to alpine forget-me-not, *Eritrichum nanum*. The Interim International Rock Garden Plant Conference, this year called "Alpines '86," takes place only once in 10 years, alternating with the traditional British International conference which is held the first year of each decade. Six hundred rock gardeners are taking a week of their summer to learn more about the plants of the American West, to take field trips into the mountains, to hear speakers from around the world.

So great is the enthusiasm of this conference, its sponsors, and its speakers, that a book has been produced in advance to capture and make permanent its intent.

Rocky Mountain Alpines is no ordinary conference report. Conceived as a reference book for understanding and growing plants of this region, the book covers a wide range of subjects and territory. It is set up in sections, the first devoted to general conditions of climate, geology and the history of botanical exploration and horticultural experiment with growing our native plants. There is a thorough history of how continental drift affected the formation of the Rocky Mountains.

Gwen Kelaidis, formerly curator of the herbarium at the University of Wisconsin, is a landscape designer in the Metro-Denver area.

We learn who first named the Colorado columbine *Aquilegia caerulea*, and where the first rock gardens of Denver were built.

There are unique maps of climatic factors such as the amount of solar energy reaching the earth in a year, which shows Colorado to be as sunny as Florida! The plant zone map is extended to compare with Europe and gives solid reasons why "hardy" in England isn't hardy in Colorado. There are maps of all the mountain ranges within the Rockies, most helpful to newcomers to the region and to those who may know one section well, but are unfamiliar with other parts of this vast area. There is even a map of all the tundra areas of the North American continent.

The second part of the book tells of natural areas of the Rockies from British Columbia to Arizona, and the many different species of plants, their associations, the communities in which they occur: the many moods of the Rockies. Blooming dates are indicated, although these can never be certain in a given year, and specific areas are named where the traveler might want to seek out a particular plant or a glorious wild flower display. The Canadian Rockies, Glacier National Park, the limestones of Idaho and Montana, the Beartooth Plateau, the Yellowstone region, the Great Basin, Pike's Peak, the Mosquitoes and Mount Evans in Colorado, the Canyonlands, the San Francisco Peaks, the White Mountains, the Sandia Mountains, the Organ Moun-

tains, all are pictured by gardener-naturalists who know them well.

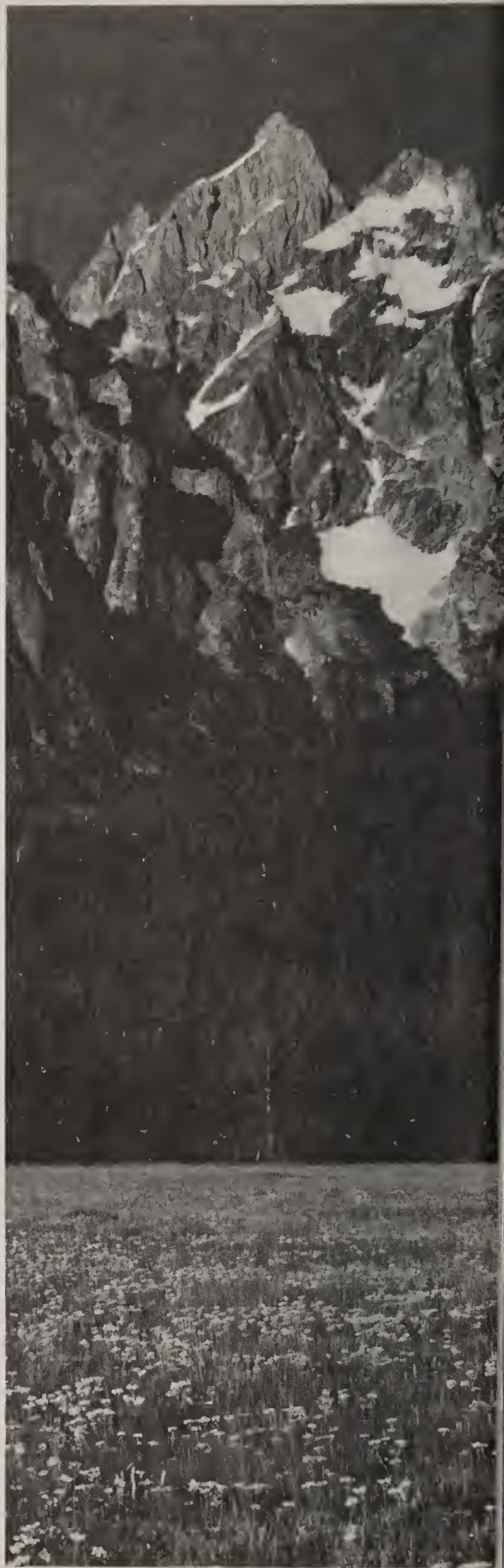
A section considers gardens at Denver Botanic Gardens that use natives, including the concepts behind the Rock Alpine and the Xeriscape gardens, the purpose and direction of the plant testing and planning which goes on here. Cacti merit a special chapter of their own, and a chapter on dryland shrubs points to the plants that can withstand western drought cycles and live on the water regime nature offers in this region. Here is material for the future development of a regional Rocky Mountain landscaping.

The final section is devoted to various ways to grow these treasures. There is an extensive list of natives to grow from seed and how to do it; tips on growing Rocky Mountain plants in sand, on slopes specially constructed to direct the wind in such a way that plants benefit; tips on special sorts of rock gardens benefiting special plants.

But who could have written such a volume with such wide-ranging subject matter on such a novel topic, one about which so little is known? This is not an area where gardening has been handed down from generation to generation, but rather a horticultural frontier where exploration is still the rule rather than the exception. The climate, the plants of the mountains and the cold intermountain basins, the very soil are novel to immigrants from the coasts, and experienced plantsmen are still few.

The book was authored by no less than 40 writers. Many are naturalists who are also gardeners, that rare breed who loves plants and wants to know the common name, the proper botanical name of each, and to grow them to perfection. These people split their summers between the study of plants in the wild and their cultivation, and so bring a unique perspective to both. Whether they write about plants in their native homes or in the garden, they share insights that come from both experiences.

Naturally the styles of the authors vary. Some chapters are dramatic:
Grassy sod-meadows alternate with



Flower-filled meadow in the shadow of the Grand Tetons.

grotesque fellfields where frost action heaves giant rocks, first upward like tombstones, then topples them on their sides in eerie heaps and clusters, ultimately moving them along in giant 'rock rivers' until they plunge over the edge of the plateau in rock slides and talus slopes; some scholarly: *These conspicuous limestone bluffs capped with volcanic rock harbor at their base an unusual complex of wetland habitats in which are found an extraordinary assemblage of recently discovered rare and disjunct plant species;* some whimsical: *From a distance the malpais seems to be only the shadow of a cloud on sunny ground, but look up. There are no clouds! Closer, it is a sinister turmoil of black foam and floe, like a spring thaw in hell;* a few almost lyrical: *Some years there are precious few flowers, but when such snow as has not been blown away gives sufficient moisture, this ridge is ethereal with the cupped violet flowers over the froth of blue gauze that is the foliage.*

The plant descriptions alone would make this a valuable book. The personalities of the authors, shining through in their varied prose, add great flavor and, at times, will amuse and perhaps even touch you. Some chapters offer charts and tables, some drawings of the plants of which they tell.

Finally, the afterword reminds us that these precious plant resources cannot be taken for granted. Despite extensive national forests and parks, abuse of the multiple-use concept threatens many Rocky Mountain plants. Only when we learn to know and appreciate the plants will we be able to set aside preserves to maintain them.

Photographs highlight the entire book. There are black and white pictures on nearly every other page; and 32 pages of color, showing many plants never before pictured in a book, crown this volume. The photos are beautiful indeed, and will convince you that natives are not to be considered second-class ornamentals. Locoweeds of all forms with their incredible pods, beautiful bear-poppy, penstemons still unknown to cultivation—you

will want to grow them as soon as you see them. The photography, like the writing, was contributed by many people, most with amateur status and professional talent.

The American Rock Garden Society and Denver Botanic Gardens are the sponsors and authors of this volume, its spiritual parents, whose members and staff have brought the idea of this book into reality in a miraculously short time after its conception.

Rocky Mountain Alpines is published by Timber Press, of Portland, Oregon. It is in an 8½ by 11 in. format, and contains 316 pages, plus 32 color plates. Retail price is \$39.95. Part of the profit will benefit DBG. The publication, to be distributed world-wide, will be available in early July in Denver.



The Reed rock garden designed by S. R. DeBoer in early 1900s.

EXOTICS OF COLORADO

Oriental Clematis, *Clematis orientalis*

by Helen Marsh Zeiner

Visitors to Idaho Springs or Georgetown in late summer are sure to see a yellow-flowered vine climbing among the rocks and shrubs along the roadsides. If you thought it was a clematis, you were right—this is indeed *Clematis orientalis* L. It is not indigenous but an Asiatic species which has made itself thoroughly at home in the Clear Creek valley, particularly near Idaho Springs.

How did this lovely oriental get all the way from Persia and the Himalayas to Colorado? It was reportedly introduced into cultivation from northern Asia in 1731. *Clematis orientalis* has long been cultivated in California and the southern states and is now occasionally planted as an ornamental in many parts of the United States. It escapes from cultivation and becomes naturalized, and can now be found growing from Ontario to New Mexico, where it is quite common.

In Colorado, it is generally accepted that *Clematis orientalis* was brought to Idaho Springs during the period of active mining in that area, probably by a miner's wife who grew the plant in her garden "back home." Unfortunately no record exists of exactly when or by whom. It is locally abundant near Idaho Springs, indicating this as a center of dispersal. It is found less abundantly near Georgetown and in other parts of Clear Creek valley.

Kathryn Kalmbach Herbarium has a 1919 specimen from Beaver Brook near Clear Creek, as well as more recent specimens from a moist roadside near Colorado Springs and from South Table Mountain at Golden, where it grew trailing over rocks and shrubs.

H. D. Harrington in 1954 reported it growing among bushes from 6,000-8,000 feet in the western half of the state. It was recently reported by W. A. Weber from Moffat and Garfield counties in the northwest corner of Colorado. Since *Clematis orientalis* is sometimes planted as an ornamental and escapes readily, more reports of naturalized plants are to be expected.

Clematis orientalis can be described as a rapidly growing, somewhat woody vine that has opposite compound leaves with thin, coarsely toothed or lobed leaflets.

Its yellow sweet-scented flowers are an inch and a half or slightly more across. Petals are lacking, but each flower has four thin, spreading or recurved petaloid (resembling a petal in some ways) sepals, more or less pubescent on both sides. Sepals are yellow tinged with green. Flowers occur solitary or a few together.

There are numerous stamens and many pistils. The styles of the pistils are plumose in fruit. The individual fruits are small dry fruits known as achenes. They are borne in a head which is often referred to as a fruit. The elongated plumose styles are sometimes described as "long feathery tails."

This clematis is usually called Oriental

Helen Marsh Zeiner, Ph.D., writes Exotics of Colorado as a regular feature in *The Green Thumb*.



Clematis orientalis

clematis, but it is also known as yellow clematis, heavy-scented clematis, and old man's beard. All are appropriate descriptive common names.

Clematis is an ancient Greek name for a climbing plant. *Orientalis* comes from the Latin and means "from the east."

Common names for the genus are Virgin's bower and old man's beard. When clematis vines have gone to seed, old man's beard is descriptive of the hoary feathery fruits. Virgin's bower, a very old and widely used name, we might assume referred to the Virgin Mary, but this is not so. Virgin's bower was the name given to *Clematis* by Gerarde, a famous herbalist of the 16th century, "As fitting to be a bower for maidens, and with allusion, perhaps, to Queen

Elizabeth, but not, as we might be tempted to imagine, to the Virgin Mary in a *riposo*, or resting scene on the way to Egypt, which is a frequent subject for pictures." (Friend 1891)

As a clematis clambers over bushes it often creates a leafy bower, so this interesting old name has some descriptive value.

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Alpine Tundra

by Emily L. Hartman
and Mary Lou Rottman

Alpine tundra south of Stony Pass near Silverton. Grenadier Range in background.

Colorado has more tundra than any other state except Alaska. The word *tundra* is Russian for "treeless plain." Originally used for arctic areas north of timberline, the term tundra was later applied to alpine terrain above timberline in mountainous areas of the northern hemisphere. Timberline, in Colorado, varies from about 12,000 ft. in the south to 11,400 ft. in the north. The vegetation of the alpine tundra is best described as dwarfed, perennial, and herbaceous, consisting primarily of grasses, sedges, herbs, and creeping shrubs. Among the non-seed plants, lichens predominate although mosses and ferns also occur.

Marr (1967) describes the alpine tundra as a land of striking contrasts in space and time. Spatial contrasts are the result of glacial and geomorphic processes; temporal contrasts are primarily related to climate.

Topography

Topographic relief ranges from sharp pinnacles, serrate ridges, and sheer cliffs to broad upland surfaces which, unlike the preceding, were never glaciated. Common features of glacial erosion are cirques, horns, aretes, and hanging valleys. Equally characteristic of the alpine tundra in Colorado, however, are gentle slopes and rolling uplands such as one

may see along Trail Ridge Road in Rocky Mountain National Park. Weathering and mass wasting have produced extensive talus deposits. Microtopographic features such as terraces, lobes, polygons, stripes, and frost boils are produced by solifluction, frost heaving, and other forces related to gravity, saturated soil, and freeze-thaw cycles of soil water.

Climate

The climate of the southern Rocky Mountains of Colorado is montane continental. The most severe mountain climate is found in the alpine tundra. Local climate patterns reflect the influence of local relief, wind, orientation, and slope. In general winter is long and cold with heavy snowfall, although much of the snow is redeposited in the subalpine forest below. Spring is short, cool, and wet with the period of heaviest snowfall often occurring in March and April (Barry 1973). The alpine summer is short and cool with frost possible at any time. Thunderstorms may occur daily and may be accompanied by hail. Fall may be very short, ending abruptly with the first snowfall in September. It is the only dry season in the tundra.

Perhaps the most significant features of the alpine climate are high winds, low air and soil temperatures, and generally low moisture availability in most sites (Moenke 1971). These combine to produce a semiarid climate to which plants have responded by many desert-like adapta-

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tions. Windswept areas may be snow-free 95% of the time, whereas other snow accumulation areas may be blanketed 11 months of the year. The growing season ranges from 0 to 70 days with the average length being 47 days (Niwot Ridge, Front Range, Barry 1973).

The interaction of microtopography and microclimate produces a microenvironment at ground level in the tundra which results in a heterogeneous mosaic of habitats and communities which may change abruptly over short distances. Compared to other mountain ecosystems, space and communities are telescoped. Consequently one must conceptualize on a small scale in order to interpret the tundra ecosystems.

Plant communities

Dry meadows occur on convex slopes where strong winds create snow-free conditions throughout much of the winter. Numerous bare and often rocky areas promote good drainage and may preclude the formation of a closed turf such as is found in the more moist meadows. Vegetation blooms early in the season completing the growth cycle before vegetation in more protected areas reaches maturity. The dry meadow is a major constituent of the alpine tundra in all ranges of Colorado except the San Juan, West Elk and Elk Mountains. In the former areas kobresia, *Kobresia myosuroides*, is the climax dominant; however, it is replaced in the latter mountain ranges by elk sedge, *Carex elynoides*.

Although moist meadows occur in all tundras of Colorado, they are most characteristic of the western mountains, the San Juan, West Elk, and Elk Mountains. Moist meadows are situated on concave slopes and flat areas at the base of both concave and convex slopes. Snow accumulation may persist through mid-summer. The moist meadow may be regarded as a complex of four communities, each with different dominants and distinct spatial occurrences within the complex (Hartman and Rottman 1985). A hairgrass (*Deschampsia caespitosa*) - alpine avens (*Geum rossii* var. *turbinatum*)

community may cover broad areas on slopes; whereas, a *Carex nigricans* - *Sibbaldia* (*Sibbaldia procumbens*) community occupies flat areas at the base of slopes. If the flat areas are moderately rocky or characterized by patterned ground, Parry's clover, *Trifolium parryi*, dominates the community. Usually the highest moist meadow community is dominated by snow willow, *Salix reticulata* ssp. *nivalis*.

Wet meadows are situated on relatively flat surfaces below late-lying snowbanks, in catchment areas in basins, and adjacent to ponds or streams. Frequently dissected by rivulets, these areas are often associated with the presence of sporadic permafrost (Ives 1974). As a result of permafrost in the substrate, the wet meadows are saturated throughout the growing season. A marsh marigold (*Caltha leptosepala*) - Drummond's rush (*Juncus drummondii*) community is characteristic of areas with standing water. Better drained sites support communities dominated by various sedges such as *Carex aquatilis* and *C. scopulorum*.

The fellfield habitat is characterized by a high proportion of weathered rock material. Soils are coarse textured, with little organic material and only rudimentary profiles (Willard 1963). Fellfields occur on windward sites, with little or no winter snow cover, thus exposing the plants and soil to severe dessication. A high diversity of species may be found in fellfield communities; however, cushion plants such as alpine nailwort, *Paronychia pulvinata*, alpine sandwort, *Minuartia obtusiloba*, alpine phlox, *Phlox caespitosa* ssp. *condensata*, and dwarf clover, *Trifolium nanum*, are conspicuous dominants.

Shrub tundra consists of shrub thickets of erect *Salix* species (short fruited willow, *S. brachycarpa*, tea-leaved willow, *S. planifolia*, and blue willow, *S. irrorata*) and associated moist meadow vegetation. These communities occur in moist depressions and drainage areas in basins. This community may be a minor component of tundra vegetation in some moun-

tain ranges or may cover entire basin floors in others such as the Sawatch Range.

Rock-predominating areas in the tundra include rock crevices, ledges, and talus. In the case of rock crevices and talus, soil accumulation in fissures or interstices is minimal and supports a random assortment of opportunistic species which show no real community structure. Rock ledges with horizontal fractures which form benches exhibit a greater soil accumulation and higher diversity of species than any other rock debris area. Certain families are well represented in these rock-predominating habitats including the mustard family, Brassicaceae, pink family, Caryophyllaceae, and saxifrage family, Saxifragaceae.

Plant adaptations

The primary adaptations of alpine plants reflect responses to an extreme and variable environment characterized by high wind velocities, low temperatures, a short growing season, lack of nutrients, and general instability of substrate (Price 1981). It is apparent that the environment, not other organisms, is the main concern with which alpine plants must deal. Although competition between species does exist in more favorable sites such as moist meadows, it is of a much lower magnitude than in most other environments. Alpine plants show many kinds of morphological (structural), physiological (chemical), and ecological (environmental) adaptations.

Morphological

One of the most striking characteristics of alpine plants is their low growth form which enables them to take advantage of the moderated environment at ground level, escaping the wind and, at the same time, capitalizing on the increased air temperatures as heat is not so quickly transported away by the wind. A plant's internal temperature in this ameliorated environment may be 40° F higher than that of the surrounding air temperature on a sunny day (Salisbury and Spomer 1964). The low growth form also enables

tundra plants to escape the harshness of winter under a protective cover of snow.

Most alpine species are perennial. The cool, brief growing season in mid-latitude mountains is not conducive to the growth of species which must go from seed to seed in a short period of time. *Koenigia*, *Koenigia islandica*, a member of the buckwheat family, is the only true annual plant in our alpine flora (Weber 1976). Tundra perennials have other adaptations which enable them to grow more rapidly or efficiently. Pre-formed flower buds, formed two to three years in advance of opening, insure rapid flowering and adequate time for seed-set after snowmelt occurs.

Many perennial herbs have relatively large underground root and/or rhizome systems which store food in the form of carbohydrates. This food supply is drawn upon during the early part of the following summer when regrowth of shoots and leaves begins. Alpine avens, *Geum rossii* var. *turbinatum*, the most common and widespread alpine wild flower, owes much of its success in growing in virtually all types of tundra habitats to its rhizomatous nature. Other species such as the alpine saxifrages, *Saxifraga caespitosa* and *S. flagellaris* ssp. *platysepala*, have small root systems but store carbohydrates and fats in their evergreen leaves.

Several adaptations which are designed to conserve water and reduce water loss from internal tissues may be mentioned. Succulent leaves are excellent water storage organs. Big-rooted springbeauty, *Claytonia megarhiza*, pigmy bitterroot, *Lewisia pygmaea*, and yellow stonecrop, *Sedum lanceolatum*, are examples of species which have acquired this adaptation. A copious covering of hairs on the exposed stem and leaf surfaces, such as illustrated by *Rydbergia*, *Hymenoxys grandiflora*, is highly effective in reducing water loss from internal tissues. Other species achieve the same result by having a heavy covering of waxy substances called cutin on their leaf, stem, or flower petal surfaces. Still another method of reducing water loss is by reduction in leaf size and, con-



Typical fellfield community, American Basin, San Juan Mountains.

sequently, reduction in evaporating surface area. Cushion plants, in particular, such as moss campion, *Silene acaulis* var. *subacaulis*, Rocky Mountain nailwort, *Paronychia pulvinata*, and alpine sandwort, *Minuartia obtusiloba*, are most effective in achieving this.

An interesting contrast exists between the amount of living material (biomass) in the belowground root and rhizome system and aboveground shoot system. Root biomass is two to six times greater than shoot biomass (Webber and May 1977). Of particular interest also is the fact that flower size and number is disproportionately greater than the vegetative system (stem and leaves) indicating the importance of reproduction among the tundra perennials. Despite the importance of the latter process many alpine species have alternative methods of vegetative reproduction by rhizomes, stolons, and bulbils. An example of a stoloniferous species is whiplash saxifrage, *Saxifraga flagellaris* ssp. *platysepala*; of a bulbiferous species, viviparous bistort, *Polygonum viviparum*.

Some growth forms found in the tundra illustrate morphological adaptations in overall shape. Cushion plants, with their rounded shape, present the most stream-

lined surface to wind and snow abrasion. The mat growth form is adapted to thin, rocky soil. Rooting along the stem, the mat attaches to a wider area than the cushion with its single large taproot (Zwinger and Willard 1972). This feature makes it an important factor in soil stabilization. The rosette growth form, typified by snowball saxifrage, *Saxifraga rhomboidea*, and many whitlow-wort, *Draba*, species, may grow tightly appressed to the substrate surface. In this manner the plant exposes a maximum surface area to light as well as receives reflected heat from beneath. The caespitose monocot is a tufted graminoid growth form found in many highly successful grass and sedge species. In meadows the tufts may be so closely spaced as to exclude other species. These graminoid sods are able to modify the microenvironment to a greater extent than any other growth form (Billings 1974).

Physiological

Considering the harshness of the alpine environment and the reduced size of alpine species, biomass production through photosynthesis is surprisingly high. On a daily basis throughout the growing season the productivity of the alpine tundra

may exceed that of many temperate environments (Webber 1974). The reason for the relatively high production rates of alpine plants is the fact that they are well adapted to low temperatures and can carry on their chemical activities at sub-freezing temperatures, beginning growth early in the spring and growing until the first snow in the fall. The rates at which chemical activities proceed are rapid. It is not unusual for some alpine plants to photosynthesize at temperatures below freezing nor to bloom while the plant is still encased within a snowbank.

Seeds of alpine plants do not germinate well at low temperatures or in dry soil conditions. This prevents germination late in the season. Seedling establishment, if it occurs, may require several years. Plants mature very slowly. Moenke (1971) states that a moss campion (*Silene acaulis* var. *subacaulis*) plant 6 inches in diameter may be over 100 years old. Drought resistance and early onset of dormancy as soon as the alpine summer wanes are other important physiological adaptations.

The reddish coloration to tundra vegetation which is often visible at the beginning and end of the growing season is due to the presence of anthocyanin pigments in the stems and leaves. These pigments which range in color from red to purple are able to convert incident light into heat which warms the internal tissues of the plant.

Floristics

There are approximately 300 alpine species in Colorado, of which 40 percent or less are arctic species (Bliss 1962). In contrast, the alpine flora of the Sierra Nevada mountains contains over 600 species; however, only 20 percent have arctic affinities (Price 1981). In the alpine tundras of the mountain ranges in Colorado thus far floristically studied, the two most important components of the alpine flora have arctic-alpine circumpolar and alpine western North American phytogeographic distribution patterns. It is interesting to note that the alpine flora of Colorado shows a greater affinity to the

Asiatic alpine flora than to the European alpine flora.

According to Weber (1965) the richest alpine communities in the southern Rocky Mountains are found in the high east-west trending ranges which lie between the primary north-south ranges. These east-west ranges tend to be more moist than the contrasting north-south ranges. Colorado endemics, species which do not occur outside of the state, increase in number in a southerly direction. Present studies seem to indicate that the San Juan Mountains of southwestern Colorado have a higher percentage of endemism than the northern ranges in the state.

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Alpine Wild Flowers at Loveland Pass

by Louise Roloff

Alpine forget-me-nots that seem to be a bit of fallen sky—bright rose moss campion and lavish white blossoms of sandwort and phlox on tight green cushions—the pip-squeak of a pika coming from the rocky talus. Do you dream of a day when you can experience this scene above the trees in the high Rockies.

But you don't climb mountains? This alpine beauty still can be accessible to you just 65 miles from downtown Denver at 11,990 foot Loveland Pass. This is a fun place to walk slowly and see what is growing in the alpine tundra.

Flowers are found in early June on the windblown ridges while snow is still deep in the bowls and subalpine zones. July and August are the best times for seeing a great variety of flowering plants, and in September and October the tundra becomes colorful with fall leaves, interesting pods and fluffy fruits.

The pass is on US 6 which leaves I-70 just east of Eisenhower Tunnel. Most vehicles continue on I-70 through the tunnel so traffic on US 6 is minimal.

From the top of the pass walk to the southwest (see map) along a trail called "the ridge" that follows up the Continental Divide. Most casual visitors go to the east up the "tourist trail." The compass directions may be confusing because the highway runs almost north-south as it crosses the pass. The ridge is usually free

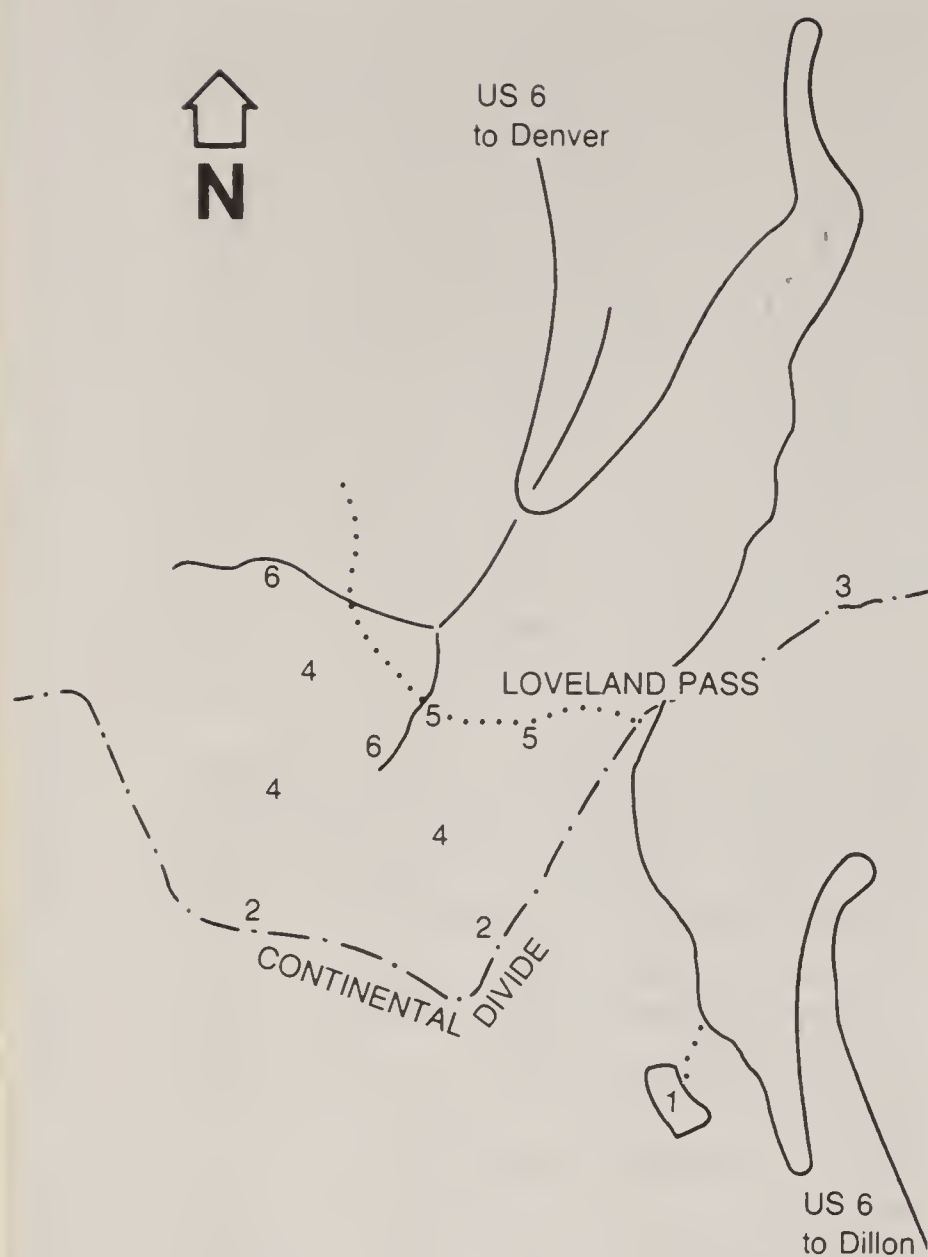
of snow in early June; but the bowl, depending upon the snowpack, is often not clear before mid-July. The greatest variety of flowers will be blooming in the bowl in late July and August.

As you walk slowly up the ridge, within the first mile, you will see many alpine flowers. Kittentails show their fuzzy purple spikes in June and early July. There will be blue alpine forget-me-nots along the path, but not in the great numbers or large mats found at slightly higher elevations in Colorado.

Pikas, yellow-bellied marmots and white-tailed ptarmigans may be seen. In August pikas are busy cutting and drying grass for winter; marmots are fat and slow, getting ready for hibernation. Both are easy to watch. For several years there has been a ptarmigan hen with chicks eating flowers and seeds on either side of the path. Other birds in this area include water pipit, white-crowned sparrow, brown-capped rosy finch, mountain bluebird, and overhead, the common raven. This a wonderful place for photography, especially with a telephoto lens.

To the east are views of Torreys and Grays peaks, both over 14,000 feet. To the far north is Pettingell, 13,533 feet, above Herman Gulch and Herman Lake. At the point on the "ridge trail" where the Continental Divide turns west, there is a good view of more mountains and ski areas. To the south lie A-Basin and Keystone. Far off to the southwest Mount of the Holy Cross is plainly visible as are the Breckenridge ski runs.

Louise Roloff, Ph.D., has led alpine hikes and plant field trips for many years and taught classes in the basics of flower identification.



Loveland Pass, 11990 feet

1. Pass Lake
2. "The ridge" on the Continental Divide
3. "The tourist trail" on the Continental Divide
4. "The bowl."
5. old wagon road
6. little streams



From any point along the ridge one can drop down into the bowl. Near the beginning of the "ridge trail" the old Loveland Pass wagon road leads west into the bowl and drops to about 11,500 feet before reaching the tall evergreen trees of the subalpine. This route crosses several small streams along which are colorful, moisture-loving flowers. If the day is good and you have the energy, get into the far western part of the bowl. There you will find a large mossy bed with yellow monkey-flowers and many rose crowns and, along the way near the willows, many large Colorado columbines.

Keep an eye open for the three little blues—Lapland gentian, Siberian gentian and alpine harebell—tiny plants seldom reaching 4 inches high. Sometimes you can see all three without moving a step.

Don't overlook the tundra in late August and September; it can be most colorful. Far up on the ridge the little white-rayed black-headed erigeron, snowlover, sibbaldia, moss campion, alpine sandwort or snowball saxifrage might still be blooming. You will see the late bloomers: arctic gentian and rose crown. In the far part of the bowl will be star gentian, rose gentian and parry gentian. The asters and senecios reach their peak displays of purples and yellows. The thick leaves of alpine spring beauty start turning red. Leaves of alpine avens color en-



tire slopes maroon and are visible from a great distance. The fuzzy seed heads of dryas paint the slope a sparkling white.

Pass Lake is a half mile beyond the top of the pass at 11,835 feet. Some white alpine forget-me-nots, that often bloom in early June, may be found on an east-facing slope above the frozen lake, to the

left. They seem to bloom a bit before the blue ones more typical of the Colorado Rockies. Be sure to get down on your hands and knees to gather in the delicate fragrance wherever you find them. Near the lake are also marsh marigolds and globeflowers in early June before they bloom elsewhere.

Some Ridge Trail Flowers

Borage Family

Eritrichum aretioides, **Alpine Forget-me-not**

Sky-blue, 5-lobed corolla with yellow center on short stems. Compact cushions of silver-hairy leaves. Early summer.

Mertensia viridis, **Green Mertensia**

Blue tubular, pendant flowers. No hairs on leaves or calyx. The common alpine chiming bells.

Buckwheat Family

Bistorta bistortoides, **American Bistort**

Tiny white or pinkish flowers in a dense raceme. On stem a foot or more tall.

Bistorta vivipara, **Alpine Bistort**

Small white or pinkish flowers in less dense raceme. Reproductive bulblets in place of lower flowers. Stem and leaves smaller than American bistort.

Composite Family

Rydbergia grandiflora, **Alpine Sunflower**

Heads 2-4 inches broad, 3-lobed yellow rays. Foliage and involucre wooly. 4-12 inches tall. Heads always face east.

Erigeron melanocephalus, **Black-headed Daisy**

White rays, heads solitary. Leaves mostly basal. Involucre with black or dark-purple cross hairs. 2-6 inches tall.

Erigeron simplex, **One-headed Daisy**

Rays blue or purplish, calyx reddish-purple. Involucre wooly with long hairs. Leaves mostly basal. 2-8 inches tall.

Figwort Family

Besseya alpina, **Alpine Kittentails**

Fuzzy purplish flowers in spikes 2-6 inches tall. Leaves basal, almost heart-shaped. June or early July.

Chionophila jamesii, **Snowlover**

White or cream flowers on short, one-sided spikes. Corolla lobes brown-tipped. Not over 3 inches tall.

Pedicularis scopulorum, **Alpine Lousewort**

Flowers pink, 2-lipped, the upper short and straight. Leaves divided into narrow, comb-like segments. 4-8 inches. Not common, found soon after starting up ridge to right in flat wet area.

Lily Family

Lloydia serotina, **Alp Lily**

3 sepals and 3 petals alike, creamy white with purple veins. Usually solitary. 2-6 inches tall.

Mustard family

Thlaspi montanum, **Wild Candytuft**

Raceme of 4-petaled white flowers. Basal rosettes of oval or spatulate leaves, small clasping stem leaves.

Smelowskia calycina, **Fern-leaf Candytuft**

Small white flowers in racemes. Leaves pinately cleft, gray-hairy.

Erysimum nivale, **Alpine Wallflower**

Bright lemon-yellow flowers. Stems low, not over 8 inches.

Pea Family

Trifolium nanum, **Dwarf Clover**

Rose flowers, 2-3 per head. mat plant with 3-foliate leaves.

Trifolium parryi, **Parry Clover**

Flowers reddish-purple in compact heads subtended with papery bracts. Leaves green and slightly toothed. Stems leafy.

Trifolium dasyphyllum, **Whiproot Clover**

Flowers 2-toned, keel pink or cream, banner and wings darker. Numerous flowers per head. Leaves bluish, hairy.



Snow-lover, *Chionophila jamesii*



Alp lily, *Lloydia serotina*



Dotted saxifrage, *Saxifraga bronchialis*



Whiplash saxifrage, *Saxifraga flagellaris*



Mountain dryad, *Dryas octopetala*

Phlox Family

Phlox condensata, **Alpine Phlox**

White or bluish flowers with 5 broad lobes abruptly expanding from a tube. Compact cushion plant.

Pink Family

Silene acaulis, **Moss Campion**

Tiny red buds, 5-notched pink petals. Flowers almost stemless. A dense cushion plant.

Minuartia obtusiloba, **Alpine Sandwort**

5 white, oblanceolate petals. Cushion plant with tiny green leaves.

Parsley Family

Oreoxis alpina, **Alpine Parsley**

Tiny yellow flowers in umbels on leafless stems. Leaves finely dissected.

Primrose Family

Primula angustifolia, **Alpine Primrose**

Bright rose 5-lobed tubular flower with yellow center. Leaves in basal rosette. Only 2-3 inches tall.

Purslane Family

Lewisia pygmaea, **Pygmy Bitterroot**

White, pink or rose petals, 2 sepals. Low rosette plant with narrow 1-2 inch long leaves.

Claytonia megarhiza, **Alpine Spring Beauty**

5 white petals veined with red. Succulent leaves turn red in autumn. In rocky areas in late July.

Rose Family

Acomastylis rossii, **Alpine Avena**

5 yellow petals. Leaves finely dissected, turn bronze or maroon in late August. Abundant. Starts blooming in late June. Favorite food of ptarmigans.

Dryas octopetala ssp. *hookeriana*, **Mountain Dryad**

8 creamy white petals. Solitary. Leaves simple, crenate, whitened beneath, mat-forming.

Saxifrage Family

Saxifraga bronchialis ssp. *austromontana*,

Dotted Saxifrage

5 oblong white petals spotted with orange, red, and yellow. Small spine-tipped leaves in tight rosettes. Found clinging to rocks.

Saxifraga flagellaris ssp. *platysepala*, **Whiplash Saxifrage**

Yellow, 5 petals, 10 stamens. Sticky hairs on leaves and stem. Basal rosette of leaves and red runners.

Saxifraga hyperborea ssp. *debilis*, **Pygmy Saxifrage**

Tiny white flowers. Leaves palmately lobed with long petioles. Uncommon. In shaded areas under boulders. Once you get to the western view on the ridge, drop down to your right into some unstable rocks. Found there with *Claytonia megarhiza*.

Saxifraga oregana var. *montanensis*.

Resembles *S. rhomboidea* but spikes are compound. Found almost anywhere in the area.

Saxifraga rhomboidea, **Snowball Saxifrage**

Tight ball of small white flowers on leafless stalk. Leaves short, rhomboid, slightly toothed, basal.

Some Bowl Flowers

Buttercup Family

Anemone narcissiflora ssp. *sibirica*, **Subalpine Anemone**

Large lemon-yellow to creamy-white sepals, no petals. 1-6 flowers per stem. Whorl of leaves below flowers. Leaves dissected, hairy. 4-10 inches tall. Abundant in the bowl.

Aquilegia caerulea, **Colorado Blue Columbine**

Blade of petals white, spurs blue. Sepals blue. Tall plants near willows in bowl. Higher among the boulders flowers often all white.

Caltha leptosepala, **Marsh Marigold**

No petals. 5-10 large white sepals, may be dark blue on outer surface. Numerous yellow anthers. Solitary. Basal leaves roundish, succulent. Wet ground.

Ranunculus adoneus, **Snow Buttercup**

5 large bright yellow petals open before the leaves can unfold. May be seen coming up through snowbank. Leaves finely dissected.

Trollius laxus, **Globeflower**

Showy 5-9 creamy sepals. Very small orange nectar-bearing petals between stamens and sepals. Solitary. Basal leaves, long petioled, deeply cleft.

Bellflower Family

Campanula uniflora, **Alpine Harebell**

Bell-shaped corolla, dark blue, with deeply dissected 5-pointed lobes. The erect bell rarely opens wide.

Figwort Family

Castilleja miniata, **Scarlet Paintbrush**

Bracts scarlet, deeply 3-cleft. Leaves lanceolate.

Castilleja occidentalis, **Western Yellow Paintbrush**

Yellow bracts entire or slightly 3-lobed. Hairy. Not over 8 inches tall.

Castilleja rhexifolia, **Rosy Paintbrush**

Bracts rose shades to white or 2-toned, entire or shallowly 3-lobed. Leaves lanceolate.

Mimulus guttatus, **Yellow Monkey-flower**

Yellow, 5-lobed, 2-lipped corolla. Short-pedicelled in racemes. 2-18 inches tall. Wet, mossy places.

Pedicularis groenlandica, **Elephanthead**

Deep pink or magenta, beak elongated to resemble elephant trunk. Flowers in long dense spike. Up to 2 feet tall. Wet areas.

Gentian Family

Ciminalis prostrata, **Siberian Gentian**

Dark sky-blue corolla, 5-lobed with small tooth-like lobes between true lobes. 1-5 inches tall. Very light sensitive, sometimes closing when a shadow blocks the direct sunlight.

Comastoma tenellum, **Lapland Gentian**

Pale blue, 4-5 lobed corolla with 2 fringed scales within. Flowers on long peduncles. 1-5 inches tall.

Gentianella amarella, **Rose Gentian**

Dull rose or lilac with fringe of hairs at corolla throat. Many small flowers on slender, erect stem.

Gentianodes algida, **Arctic Gentian**

Flowers white or greenish-white with dark streaks on outside of each lobe. Large, deep cup-shaped corolla on short stem. On grassy tundra often blooming when alpine avens leaves have turned maroon.

Swertia perennis, **Star Gentian**

Star-shaped, 5-lobed, deep blue or bluish-purple corolla. 6-12 inches tall. Wet meadows.

Heath Family

Kalmia polifolia ssp. *microphylla*, **Bog Laurel**

Rose flowers with 5 united petals and 10 stamens. Woody. In cold, wet areas in the far part of the bowl. Plant very low at this altitude.

Primrose Family

Primula parryi, **Parry Primrose**

Bright rose flowers with yellow centers. In umbels. Up to 15 inches tall. In or along icy streams. Abundant here.



Arctic gentian, *Gentianodes algida*

Stonecrop Family

Clementsia rhodantha, **Rose Crown**

Pink or rose petals in compact racemes. Bee pollinated. Succulent, thick, flat leaves. Up to 12 inches tall. Blooms in late season. Wet areas.

Rhodiola integrifolia, **King's Crown**

Petals deep red-purple. In flat-topped clusters. Fly pollinated. Some bloom early at top of pass.

Sedum lanceolatum, **Stonecrop**

Many yellow star-like flowers. Buds red. In cymes. Succulent leaves in compact rosettes.

Willow Family

Salix arctica, **Arctic Willow**

Catkins many-flowered, 1-2 inches long. Apex of leaves pointed. Not reticulate. Prostrate creeping plant.

Salix nivalis, **Snow Willow**

Catkins ½ inch or less, few flowered. Leaves strongly netted-veined with rounded, blunt apex. Prostrate creeping plant.

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Velma A. Richards
Editor

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"THE PATH AMIDST THE FLOWERS
WAS NOT SWEEPED FOR THE GUEST"

—*The Poet DU FU (A.D. 712-770)*

Reminiscences of A Horticulturist in China

by Merle M. Moore

It was a cold, windy January morning in 1967 as I caught my first glimpse of The People's Republic of China from a hilltop at Lokmachau in the New Territories of Hong Kong. In the mist-enshrouded landscape before me I could barely discern the few farms and distant hills of Guang Dong Province lying tantalizingly out of reach of American tourists at that time. On a brief vacation from my assignment as a Peace Corps Volunteer in Thailand, I was enjoying the early stages of what was to become an enduring fascination with and interest in the people and cultures of Asia.

A subsequent position with the U.S. Agency for International Development in South Vietnam provided an opportunity for further travel in the region. It also heightened a growing desire to visit The People's Republic of China and encounter firsthand the venerable culture and people of that mysterious, forbidden land.

Nearly 20 years would pass before this opportunity would finally evolve, not out of a once conceived career in the foreign service but as a result of returning to my initial career choice—horticulture.

In May 1985 Dr. Richard Harris, Professor of Horticulture at the University of California at Davis, invited me to join a delegation of landscape horticulturists from throughout the United States; at the request of the Botanical Society of China

we were being invited to visit the People's Republic of China and exchange information with our Chinese counterparts on current landscape horticultural practices. Through organized meetings and professional discussion sessions as well as informal gatherings we would talk with our colleagues in five Chinese cities and observe firsthand their practice of landscape horticulture. Needless to say, this prospect of representing the Denver Botanic Gardens as a member of such a prestigious delegation was most exciting; it offered unequalled opportunities for scientific exchange between botanical gardens in China and our own.

Were it not for a supportive board of trustees, a number of whom contributed personally to the fund set up to make my participation in the delegation possible, the adventure would have ended there. However, through their generosity, I was able to represent the Gardens as a member of the delegation, make valuable contacts with my Chinese counterparts at botanical institutes in five different geographical regions of the country and lay the groundwork for a tour to China by our Botanic Gardens members in October 1988. It was a very productive, educational and fascinating three weeks.

Arrangements for our visit were handled on this side of the Pacific by the Citizen Ambassador Program of People to People International, with its headquarters in Spokane, Washington. Founded by President Eisenhower in 1956, People to People International was established to encourage "increased visits by citizens

Merle M. Moore, executive director of Denver Botanic Gardens, has long had a keen interest in both the peoples and the flora of the eastern Asian countries.

of one country to another to give each the fullest opportunity to learn about the people of other nations . . ." Many of you may be more familiar with the Sister Cities Program in which the city of Denver is an active participant. In fact, the most recent addition to the roster of Denver Sister Cities is Kunming, China, a city visited on our tour.

William G. Gambill, Jr., Director Emeritus of Denver Botanic Gardens, was also a member of the visiting delegation. We agreed to be roommates for the trip, a development I enthusiastically endorsed as I looked forward to having ready access to an accomplished taxonomist as we immersed ourselves in the extensive and diverse flora of the Chinese continent. Having tramped through tropical rainforests in Sabah and the highlands of peninsular Malaysia with Dr. Gambill on an earlier trip, I had ample evidence that he would be an intrepid traveling companion undaunted by the adventures we were bound to encounter in a journey to China.

Following a pre-tour briefing in Seattle, we boarded our flight on October 2 for Hong Kong and on to Beijing. Once in China we were under the auspices of the Chinese Academy of Science, a distinc-

tion that set our group apart from the usual crowd of tourists and on several occasions allowed us certain freedom of movement that contributed to the enjoyment and accomplishment of our overall experience.

As we drove from the airport to the Xiang Shan (Fragrant Hill) Hotel in the hills northwest of Beijing we were impressed by the extensive and colorful displays of potted annuals (salvia, dahlias, asters, asparagus fern, chrysanthemums and blackeyed susans) to be found on street corners, in front of government buildings and at the entrance to our hotel. They were a reminder of the October 1 celebration of the founding, in 1949, of the People's Republic of China, an event conspicuously celebrated throughout Beijing.

Expecting to find Chinese hotels to be austere and unimpressive, I was delightfully surprised by the beautiful, I.M. Pei-designed Xiang Shan Hotel. Not only was the architectural style of the building very striking but the surrounding garden and the general beauty of the setting in the hills above Beijing added to its dramatic effect. Magnificent specimens of Chinese lacebark pine, *Pinus bungeana*, Chinese pine, *Pinus tabulaeformis*,



Xiang Shan Hotel in its beautiful garden setting.

and maidenhair tree, *Ginkgo biloba*, were scattered over the grounds and through the gardens of the hotel.

Our first morning in Beijing was spent at the Science Hall where four presentations were given by members of our delegation. Subjects ranged from the latest advances in growing, training and transplanting trees to using plantings in and near cities for climate modification and pollution control. Following lunch at a nearby restaurant—the beginning of a gastronomic tour de force through five of the regional cuisines of China—we returned to the Beijing Science Hall for a more informal exchange of questions and answers on a wide range of horticultural subjects.

While waiting for the afternoon session to begin, I enjoyed a delightful exchange with a group of Chinese students who were eager to help me identify some trees and shrubs growing adjacent to the building as well as practice their English. That evening our delegation, along with several smaller visiting delegations from England (beekeepers), Sweden (medical technicians) and the U.S. (dental hygienists), was treated to a reception held at the Beijing Hotel. In addition to the dramatically presented feast which had been prepared for us there were various singers, dancers and instrumentalists who performed for our enjoyment.

Visits to important historical sites and to the Beijing Botanical Garden filled our next three days in Beijing. In each instance we were accompanied by our technical guide from the Chinese Academy of Science who also acted as our principal interpreter. Upon arrival we were usually met by those Chinese officials responsible for the planning and management of the horticultural/botanical collections at each site.

At the Ming Tombs, where 13 of the 16 Ming emperors chose to be buried, ripening persimmons, *Diospyros* 'Kaki', gave the appearance of orange ornaments hanging from the trees in adjacent orchards. Just outside the entrance to the Ming Tomb complex local farmers had set up a fruit market along both sides of the

road to sell the persimmons as well as several other fruits which appeared to be crab apples and green plums. In Imperial times none but the deceased Emperor and his funeral cortege were permitted to traverse this road; any other person would be killed. Seeing the fruit vendors and tourists by the hundreds now visiting the tombs helped to focus in my mind the tremendous changes China has gone through in the past and is experiencing even more rapidly at the present. It will be most interesting to follow over the next few years the evolution wrought by this momentum for change which we experienced during our visit to China.

Our visit to the Beijing Botanical Garden (Northern Garden), situated at the foot of Mount Shouan and incorporating the plantings within the Shi Fan Pu Jue Temple (Temple of the Sleeping Buddha) became, in retrospect, more interesting as our tour of China progressed. This is principally because we saw few botanical gardens that had such a park-like feeling and used large displays of bedding plants and perennials simply for their colorful effect.

While the introduction and acclimatization of plants in China can be traced back 7,000 years, these early introductions most often were related to plants of agricultural or medical interest. It was not until 1929 that the Sun Yat-sen Botanical Garden was established in Nanjing to apply modern scientific methods to the study of plants. In 1934 the two professors responsible for establishing the Nanjing garden set up a new botanical garden in Lushan. Located to the south and west of Nanjing, the Lushan Botanical Garden with its higher elevation and much greater rainfall concentrated on collections of conifers, rhododendrons and rare and endangered plants of cooler, sub-tropical regions. During World War II both gardens were damaged extensively and further development of a national system of botanical gardens was halted.

Following the founding of the People's Republic of China, the Academy of Science was established making possible re-



A colorful bed of annual flowers at the entrance to the Magnolia Garden, Beijing Botanical Garden.



Entry gate to the Temple of the Sleeping Buddha within Beijing Botanical Garden.

construction, in the mid-1950s, of the botanical gardens in Nanjing and Lushan. By the end of that decade a national system of botanical institutes, each with a botanical garden, had been developed. Today there are 21 botanical gardens extending from the Russian to the Burmese borders, and from the center of the continent to the east coast. National conferences held by the Academy of Science in 1963 and in 1978 determined the three priorities for botanical gardens in China today. These priorities, as published in *The Botanical Gardens of China* by Yu Te-tsun, are:

"1. Exploit wild-plant resources, introduce important plants from abroad, and collect plants which are rare, precious or on the verge of being extinct, so as to enrich the variety of flora in China and cater to the needs of China's national construction.

2. Study the pattern of the growth of plants, do research on the adaptability of the plants introduced, find out the economic characteristics of these plants and look into the laws of genetic variation, sum up the experience gained in the introduction and acclimatization of

plants, perfect the relevant theories and improve the methods.

3. Set up exhibition centers which integrate beautiful landscape with scientific research and activities to spread the knowledge of botany."

As we visited other botanical institutes during the course of our tour, a routine emerged which included a briefing usually given in that part of the institute where the exhibits and displays were located, a tour of the botanical garden and the presentation of papers by members of our delegation and, less frequently, by our Chinese counterparts.

One cannot go to Beijing without visiting the Forbidden City, now referred to by the Chinese as the Imperial Palace. For me the Forbidden City held a special interest. I had visited Taipei (Taiwan) on several occasions and each time, toured the National Palace Museum which houses a remarkable collection of art treasures and jewelry that was smuggled out of the Forbidden City, and subsequently out of China, by the Guomindang forces led by General Chiang Kai-Shek. More than 200,000 pieces of art are contained in that collection, most of them



Near the Emperor's Garden, Forbidden City.



stored in caves deep in the mountain behind the museum buildings. In spite of this staggering loss there remains much to be seen of the Imperial treasures and life style in the Forbidden City today. Of particular interest was the increasing use of plants as one approached the heart of the Forbidden City where the Emperors and their families actually lived.

Adjacent to the Forbidden City, just outside the Gate of Heavenly Peace, lies Tian'anmen Square. This immense public square can accommodate gatherings of more than a million people. It is also the site of Mao Zedong Memorial Hall where the body of Chairman Mao lies in state in a crystal sarcophagus. The exaggerated scale of other buildings surrounding the square is exemplified by the Great Hall of The People which seats 10,000 people in its main assembly hall. During Richard Nixon's visit to China dinner was served for 5,000 guests in one of its dining halls. The beds of brightly flowering annuals and roses scattered sparingly around the square contribute little to bringing the scale into a comfortable human perspective.



Rose beds outside Mao Zedong Memorial Hall, Tian'anem Square, Beijing.

Visits to the Temple of Heaven and to the Summer Palace with its wonderfully landscaped grounds and serene Kunming Lake (complete with the Machiavellian Empress Dowager's extravagant marble boat built with funds embezzled from the Imperial Navy) concluded our introduction to the use of landscape plant materials in historical and public "parks" in and around Beijing.

In all this stimulating Beijing adventure, two highlights stand out above the others. The first was a visit to the Great Wall at Badaling, northwest of Beijing. Seeing this incredible architectural marvel at any time of the year must be an awe inspiring event. However, to be atop the Great Wall on a clear October morning, amidst the autumnal glory of the smoke tree, *Cotinus coggygia*, painting the hill-sides with a brilliant burgundy hue, was a sight to be forever remembered. The exhilaration of seeing the Great Wall, juxtaposed with that dramatic fall coloration, was tempered by the realization that many human lives were sacrificed in the building of this monument to the absolute power wielded by the Chinese emperors.

The second was the opportunity to see Dr. K. H. Shing again and meet his family. Dr. Shing, a taxonomist specializing in ferns and fern allies, came to Denver as a visiting professor in 1981-1982 under the auspices of the University of Colorado in Denver. While here, he spent many hours at the Botanic Gardens and assisted us in reviewing our modest collections of both living and preserved ferns. In Beijing Dr. Shing is responsible, as Curator of the Fern Herbarium of The Institute of Botany, for more than 150,000 preserved specimens of ferns and fern allies maintained in the National Herbarium of the Academy of Science. He is one of 30 staff taxonomists at the herbarium which comprises a total collection in excess of 1.3 million preserved specimens. With minor herbaria located at each of the 21 botanical institutes throughout the country it became increasingly evident during our tour that taxonomic research is currently of con-



Dr. William G. Gambill, Jr., Director Emeritus of Denver Botanic Gardens and Dr. K. H. Shing in the National Herbarium of China.

siderable importance to the Chinese. In fact, Chinese taxonomists are expected to spend 3-4 months of every year in the field conducting their studies.

Meeting Dr. Shing's family at their residence was both a rare privilege and a very enjoyable respite from our otherwise tightly scheduled daily routine. After a refreshing glass of wine produced from grapes grown at the botanical institute where Dr. Shing works, we settled back to enjoy a most delicious lunch his wife had prepared. His daughter, Hsao Wen Shing, a cute and perky 16 year old, had received special permission to come home from school and join us for lunch and it was delightful having her tell us, in very good English, about her school and the subjects she was taking.

Dr. Shing's apartment, located near the Beijing Zoo, consists of a small "sitting room" where we enjoyed our lunch, two bedrooms, a small kitchen area and a bathroom. While it would seem quite cramped and spartan by our western



Dr. Shing and his family in front of their Beijing apartment.

standards, Dr. Shing and his family enjoy a degree of "luxury" not known to a great majority of Chinese people. Dr. Gambill shared my sense of relief to find Dr. Shing in good health and obviously having made a relatively uneventful transition from living two years in the United States and then returning to his home and family in The People's Republic of China. The time we were able to spend with Dr. Shing, to reminisce about his two years in the U.S. and to get a sense of the impact that experience had on him was woefully inadequate. Nor was there sufficient time for us to share with him our interest and excitement about the experiences we were having in his country. I look forward to the possibility that we will meet again in October 1988, when a group of Botanic Gardens members will join me for a tour of China. It will be a pleasant opportunity to once again share our experiences of the intervening years.

In the next issue of *The Green Thumb* I will conclude my article on China by

sharing with you reminiscences of our visits to Chengdu, the capital of Sichuan Province which is noted for its variety of bamboo products and its spicy cuisine; Kunming, capital of Yunnan Province, Denver's newest Sister City and the World War II home of the Flying Tigers; Guilin, with its incredible landscape so reminiscent of classical Chinese landscape paintings; and Guangzhou, a city of beautiful gardens bustling with the energy of China's new freedom of trade with the outside world.

The Kathryn Kalmbach Herbarium

by Helen Marsh Zeiner

In the winter 1973 issue of *The Green Thumb*, a comprehensive report on the Kathryn Kalmbach Herbarium was presented. Although brief reports had appeared from time to time in *The Green Thumb*, this was the first complete and detailed account of the herbarium from its beginnings, a period of about 30 years. It is once again time to report on the Kathryn Kalmbach Herbarium, an important department of Denver Botanic Gardens.

Casual visitors to a herbarium often expect to see a collection of culinary or medicinal herbs. The misunderstanding arises because of the similarity of the two words, herb and herbarium, both derived from the Latin *herba*. "Herb" to the botanist means any non-woody flowering plant. A herbarium, therefore, is not a collection of culinary, medicinal, or aromatic plants as the common use of the word herb might imply. It may include all plants, both woody and non-woody.

The plants are carefully pressed and mounted, then labeled with scientific name, place of collection, habitat, name of collector, and other pertinent information, and arranged systematically for ready reference and study. A herbarium is a reference library of pressed plants—a place to learn and not merely a "morgue for dead plants" as some irreverent person once said. Properly prepared specimens in a herbarium are permanently preserved and available indefinitely for study.

The value of a herbarium becomes apparent when one compares learning from an actual specimen, even though pressed and dry, with learning from a written description which may be lengthy and hard to understand or, on the other hand, incomplete. Herbarium specimens are invaluable to taxonomists for reference, study, and comparison. A herbarium is an important source of information about the vegetation of an area, telling us much about distribution, both local and widespread. In identifying new plant materials, herbariums are valuable for comparison, often making it easy to identify the plant in question.

The Kathryn Kalmbach Herbarium originated about 1943 as a project of the Colorado Forestry and Horticulture Association. Kathryn Kalmbach and George Kelly were leaders of a group of volunteers who wanted to start a collection of pressed plants of Colorado, to provide a means for members of the association to see and identify native plants and to provide general information on the flora of the state. This group of interested people made many special collecting trips as well as collecting as individuals. The Colorado Mountain Club also helped with this project.

Helen Marsh Zeiner, Ph.D., is curator of the Kathryn Kalmbach Herbarium serving as an invaluable volunteer at Denver Botanic Gardens.



Dr. Zeiner arranging fresh flower display in the lobby court case.



Loraine Yeatts uses the open-arm stereomicroscope for identifying a plant.



Educational displays on the Kathryn Kalmbach Herbarium balcony.

When the Colorado Forestry and Horticulture Association acquired Horticulture House at 1355 Bannock Street, the herbarium officially came into existence. It was announced in the January-February 1947 issue of *The Green Thumb* that there would be facilities in the basement for a herbarium of Rocky Mountain plants, and that Mrs. E. R. (Kathryn) Kalmbach would be in charge. The hoped-for botanical facilities were never fully developed but the herbarium did have adequate storage space. The tables in the combined library and meeting room were used for preparing and studying specimens, obviously not an ideal arrangement.

Mrs. Kalmbach was designated as chairman of the Herbarium Committee which was comprised of the volunteers working in the herbarium. It was always a working committee, and has remained so, with all committee members serving as volunteers in the herbarium.

As the collection grew, both by purposeful collecting and by gifts of personal collections, it became necessary to recruit additional volunteers for help in preparing the specimens for inclusion in the herbarium. Members of Home Garden Club of Denver as well as other interested persons responded to the appeal and an active group met weekly at Horticulture House to prepare specimens.

Money was a real problem, and necessary supplies such as mounting paper were donated.

In March 1959 the Colorado Forestry and Horticulture Association moved to Botanic Gardens House at 909 York Street. Here the herbarium was housed in part in a small room adjoining what was at that time *The Green Thumb* office, now the administrative office of the outdoor gardens, and in part in converted linen cupboards in the upstairs hall. Workers had to set up tables either in *The Green Thumb* office or in the hall. Specimens were more readily accessible than they had been at Horticulture House, but it was a very inconvenient arrangement both for workers and those who wished to use the herbarium. It was during this

period that the first standard metal herbarium case was acquired.

When the Botanical Gardens Foundation of Denver merged with Colorado Forestry and Horticulture Association in 1960, this facility became the official herbarium of Denver Botanic Gardens. Kathryn Kalmbach remained chairman of the committee and in charge of the herbarium until her death in 1962. It was named the Kathryn Kalmbach Herbarium in her honor. Following Mrs. Kalmbach's death, Helen Zeiner, Ph.D., was appointed chairman of the committee to direct work in the herbarium.

By April 1963 the herbarium had acquired three new metal cases. A stereoscopic microscope for use in the herbarium and by Botanic Gardens staff was also acquired during this period.

The small room designated for the herbarium was soon needed for duplicating machinery, and the herbarium was moved to the conference room (now converted into office space) which it shared with the mycology group. This room, although crowded, had one large table which could be used as a work table. Unfortunately it was necessary to schedule meetings here, limiting the availability and usefulness of the herbarium.

In March 1971, the herbarium was moved to its present quarters in the Education Building of Boettcher Memorial Center. This large room provided space for expansion. By 1973, the herbarium had 16 storage cases and for the first time a sink with running water, so necessary for working with plants. It also provided tables for workers and others who used the facility. There was also a small store room. At last, the Kathryn Kalmbach Herbarium had adequate working space, and boxes of plants which had been stored could now be processed.

The collection had grown to 5,000 sheets, prepared under very inconvenient working conditions. Late in the winter of 1971 the University of Denver Herbarium was moved to Denver Botanic Gardens and incorporated into the Kathryn Kalmbach Herbarium. This doubled the size of the facility and

KATHRYN KALMBACH HERBARIUM
DENVER BOTANIC GARDENS
1311



NAME *Calligonum involucratum* (L.) Gray
PLANTS OF
NAME
LOCALITY *Chaco Springs alt. 10,000* DATE *Sept 15, 1961*
HABITAT *Shaded* COLLECTED BY *J. S. H.*
REMARKS *Same as last specimen - Pinellia Bluffe.*



KATHRYN KALMBACH HERBARIUM
DENVER BOTANIC GARDENS
3436

LOCALITY *Chaco Springs alt. 10,000*
DATE *Sept 15, 1961*
COLLECTED BY *J. S. H.*
HABITAT *Shaded*
REMARKS *Same as last specimen - Pinellia Bluffe.*



KATHRYN KALMBACH HERBARIUM
DENVER BOTANIC GARDENS
CARYOPHYLLUS X C. ANTHORUS A. N. S. P. (det. A. N. S. P.)
CULTIVATED - GOLF COURSE, DENVER GOLF COURSE
DENVER BOTANIC GARDENS, 1000 St. Andrews,
West Perennial Garden, accession 4761584.
PLANTED BY *James W. Wiegman*
No. *967* Date *9 August 1961*

brought it to approximately 10,000 sheets. The herbarium continues to grow, and now there are storage cases with more than 23,000 specimens accessioned.

Included in the herbarium are native Colorado plants; special collections from Mt. Goliath, Chatfield Arboretum, the montane Walter S. Reed Botanic Garden, and South Table Mountain; the J. J. Waring allergy plant collection; cultivated plants; voucher specimens of plants grown at Denver Botanic Gardens; and plants from other states and foreign countries.

To simplify use, plants are filed first as lower vascular plants, gymnosperms, monocots, or dicots, then alphabetically by family, genus, and species. To date we have been able to maintain a card file index by genus.

From the very beginning Kathryn Kalmbach Herbarium has been staffed by volunteers selected for their knowledge of plants. At the present time 10 volunteers work in the herbarium—some professional botanists and others amateur botanists with "professional" ability. Dr. William G. Gambill, Jr., Director Emeritus of Denver Botanic Gardens, is the official taxonomist for Denver Botanic Gardens. Dr. Janet Wingate, as well as serving as a volunteer, is a part-time staff member employed to collect and prepare voucher specimens of the plants cultivated at Denver Botanic Gardens. Dr. Helen Zeiner has served as chairman of the committee since Mrs. Kalmbach's death in 1962, and in 1973 was named honorary curator of the Kathryn Kalmbach Herbarium "in recognition of outstanding volunteer service."

The Kathryn Kalmbach Herbarium is unique in that it provides a number of services to the public. Many times plants have been identified for individuals; other persons have used our specimens to make their own identifications. Classes from high schools and local colleges have visited the herbarium and some have spent time studying plants in our collection.

Classes which make direct use of the

herbarium, such as taxonomy classes, have been scheduled.

The Committee maintains exhibits of interest to the general public on the display balcony, an important part of the Kathryn Kalmbach Herbarium. Some of these displays are of a "museum type" and changed infrequently. Such a display is a lichen exhibit, so popular with some teachers that it is included in work sheets for classes visiting the Gardens. Other displays are changed at more frequent intervals. Some are seasonal. A popular feature has been a display of fresh plant material, particularly Colorado wildflowers, as an educational tool for the public who want to know "what flower is this?"

In the fall of 1984 a glass enclosed case in the lobby court was provided so that the herbarium staff could display fresh wildflowers in season in a location where they would be easily seen. During the winter months, a display of Colorado evergreens aroused a great deal of interest. This was followed by exhibits of winter twigs and forced twigs. During the spring and summer, Colorado wildflowers are featured.

The Kathryn Kalmbach Herbarium is still a small herbarium whose very existence is due to the hard work of loyal volunteers. As Denver Botanic Gardens grows, the Kathryn Kalmbach Herbarium will continue to grow and increase in importance. It is an asset to Denver Botanic Gardens and to the city of Denver.

Reference

Zeiner, Helen Marsh. The Kathryn Kalmbach Herbarium, an update. *The Green Thumb* 30(4):98-103.

The Kathryn Kalmbach Herbarium is open to the public Tuesdays 9 a.m. to 3 p.m. and Thursdays 10 a.m. to 2 p.m.

A Mountain Meadow—Mt. Falcon Park

by Peter Root

Perhaps the most difficult part of a discussion of mountain meadows is defining them. The term can be applied to a wide variety of habitats ranging from large permanent mountain grasslands known as parks to sites of former forests or even spaces between trees in an open ponderosa pine forest.

Meadows can be wet or dry; at higher altitudes they resemble tundra; as we near the foothills they take on many characteristics of the plains. They cannot be described as having a single vegetation type and are influenced by adjoining habitats. The wide variety of plants living in meadows makes them a spectacular feature of the scenery during the flowering season.

A very accessible example of a mountain meadow near Denver is Mt. Falcon Park, part of the Jefferson County Open Space system and located near Indian Hills. The upper part of the park contains a large successional meadow which was probably cleared about a hundred years ago. When forests are removed, vegetation recovers through an orderly series of stages called succession. In some cases grazing, fire or climatic factors delay reestablishment of forest and a successional meadow results.

Peter Root, a volunteer at Denver Botanic Gardens, leads wild flower field trips and works in the Kathryn Kalmbach Herbarium, specializing in ferns and fern allies. He is also a volunteer naturalist at Roxborough State Park.

The meadow, which can be entered through a ponderosa pine forest, is a gently sloping bowl draining eastward. In early summer it is visually dominated by green grasses, but among them are many plants with more conspicuous flowers. The composites range in size from the very small white pussy toes, *Antennaria* species, to the large yellow and red flower heads of *Gaillardia*.

They are joined by several species of legumes in the genera *Astragalus* and *Oxytropis* which have flowers ranging from white to blue and purple.

Along the south side of the meadow the edge of a forest of ponderosa pine and Douglas-fir is advancing. Among scattered trees kinnikinnick, *Arctostaphylos uva-ursi*, a forest floor species, is mixing with meadow plants. The western tanager can be seen and heard here. A very noticeable plant is the green gentian, *Frasera speciosa*, looking in its young stage much like a plastic houseplant with its large cluster of light gray-green leaves. Its 2-foot tall stalk of green flowers justifies another common name, monument plant. The bright yellow pea flowers of golden banner, *Thermopsis divaricarpa*, bloom here in spring and early summer.

Some large ponderosa pines have remained at the east edge of the meadow along with patches of aspen where Colorado blue columbine, *Aquilegia caerulea*, may be found. Its blossoms, appearing like blue and white balloons lightly tethered by their slender stems, are im-



Pussytoes, *Antennaria* sp.



Green Gentian, *Fraseria speciosa*



Colorado Blue Columbine, *Aquilegia caerulea*



Scrub Oak, *Quercus gambelii*



80 Spotted Coral-root, *Corallorhiza maculata*



Penstemon sp.

pressive even to those who usually ignore wildflowers.

The soil here is richer and, after early summer rains, yellow mushrooms of the genus *Suillus* come through the litter like thick, sticky pancakes. The clustered purple and yellow flower stalks of the spotted coral-root, *Corallorhiza maculata*, a saprophytic orchid, bloom in the humusy soil under the pines.

In the central part of the meadow the dark blue flowers of blue-mist penstemon, *Penstemon virens*, make a collective display which truly lives up to its name. Occasional plants of the one-sided penstemon, *P. secundiflorus*, are conspicuous with their lavender-pink blossoms. Contrasting with these against the green background of grasses are flower heads of

orange arnica, *Arnica fulgens*.

A curious feature in the meadow is the presence of several clumps of scrub oak, *Quercus gambelii*, which in this location approaches both the northern and the upper altitude limits of its range. Although the oaks appear to have died back to the ground recently, they are still sprouting at their bases.

It is commendable that open space land has been set aside near Denver; however, complacency must be avoided. Although this land may be safe from development, the pressure for diverse recreational uses will continue to present problems for land managers. Without constant vigilance by managers and citizens open space land could eventually degenerate into well manicured suburban parks.



Golden Banner, *Thermopsis divaricarpa*



Arnica, *Arnica fulgens*

FOCUS ON Mango, *Mangifera indica*, IN THE BOETTCHER MEMORIAL CONSERVATORY

by Peg Hayward

The mango is one of the oldest cultivated tropical fruits. Its original home is believed to have been somewhere in eastern Asia and the Malayan archipelago and it seems to have been cultivated in India for more than 4,000 years. Akbur, who ruled northern India in the 16th century, is said to have planted 100,000 mango trees at a time when large orchards were unheard of. The Portuguese probably carried the mango to East Africa where it is common. Now mangoes are widespread in the tropics where they are valued for shade trees as well as for their fruits.

Mangifera indica L. is the best known and most important of the some 40 trees that comprise the genus. Mangoes are handsome broad-spreading evergreen trees with rounded tops. They may attain a height of nearly 100 feet with a spread of 125 feet. These trees often live to be 100 years old. Leathery dark green leaves of the mango have long drawn-out tips which point downwards. New leaves attract attention with their coppery-red color. Filmy fragrant flowers grow in panicles. They have yellowish-green sepals and creamy petals with darker yellow ridges on the surface, but the petals turn pink as the flowers age.

Smooth-skinned fruits, which dangle from the twigs, vary enormously in size

and shape from almost round to narrowly oblong or oval and are slightly beaked on one side. When ripe the skin may be yellow or orange with a red flush or they may be greenish yellow depending on the variety. Each fruit contains a large flattened seed covered with coarse fibers and surrounded by yellow or orange pulp. A superior variety, properly ripened, is one of the world's finest fruits. An inferior or unripe mango is fibrous, tough and has a flavor resembling turpentine.

Fruit of the mango is a better source of vitamin A than the orange and a fair source of vitamins B and C. Mangoes may be eaten raw, stewed, frozen, or made into preserves and chutney. The mango is a staple article of food during the hot months in the tropics where it is called the "king of fruits".

Mangoes are in the poison ivy and poison oak family, *Anacardiaceae*. Some people are sensitive to the raw fruits and may suffer from a poison-ivy-like rash about the lips and face as a result of eating them. Other related plants are sumac and cashew nut.

Hindus regard mango leaves as symbols of happiness and prosperity and use them on festive and religious occasions.

Besides being double-duty trees, ornamental as well as food producing, mango wood is used for doors, window frames, packing cases, boat building and plywood.

Peg Hayward, long associated with the guide training program for Boettcher Memorial Conservatory, writes "Focus On" as a regular feature of *The Green Thumb*.

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Fruit-bearing branches of the mango tree, *Mangifera indica*.

A Benefit for the "Greening of Denver"

The Garden Club of Denver, founded in 1916, has been involved in many ways with public gardens and civic plantings in the Denver area. Currently it is planning a fund-raiser to benefit both Denver Botanic Gardens and the "greening of Denver," a project for improving the ambiance of Lower Downtown with street plantings.

The Garden Club, in cooperation with Historic Denver and Denver Botanic Gardens, will host a holiday table settings show on December 5 and 6 in the Ice House at 1801 Wynkoop Street in Denver. Half of the funds raised will be used to implement the first phase of the "greening of Denver" project—street plantings in the historic warehouse district of Lower Downtown; the other half will benefit Denver Botanic Gardens.

The new streetscape design for downtown Denver is an integral part of the recently adopted Downtown Area Plan unveiled in May by the city and Denver Partnership and approved by the city council in July. City appropriations will be used to fund the streetscape research design through Denver Partnership, but implementation of the landscaping designs must be funded separately.

Because of the large number of improvements called for in the plan for just Lower Downtown, city officials and downtown business interests have welcomed support from citizen groups such as the Garden Club of Denver to help bring the landscaping portion of the plan to fruition, noted Mary Roberts, historic

preservation consultant for the Denver Planning Office.

Sara Jane Seward, project manager for Denver Partnership's involvement in the streetscaping, says research is proceeding using photographs dating from 1860 to the present to determine what has occurred historically along the streets of lower downtown. "We're looking at the streets in the 24-block area as they have appeared over time—studying materials used, changes that have occurred, and what design remnants exist or have completely disappeared. We would like to determine what historical threads, in fact, have been genuine to the street design of the area.

"We will work with Lower Downtown property owners and Historic Denver to gain input, and then obtain approval from the city for the overall streetscape plan."

Seward and Roberts say that the actual project implemented with assistance from the Garden Club of Denver will be a section in lower downtown where the need is greatest.

"Several sidewalk areas have not been improved in recent memory," Seward said, "because the area was primarily a warehouse district until the 1960s. While the loading dock atmosphere provides interesting character, sidewalks need to be improved to create a safe and attractive pedestrian environment."

As research and planning progress in coming months, representatives from the Garden Club will meet with Historic



A designer's rendering of a potential streetscape plan in Lower Downtown as a part of the new master plan for the greening of Denver.

Denver and Denver Partnership to select the specific site for this "greening of Denver" project.

The December benefit will be one of the few opportunities for the general public to visit the Ice House Design Center, usually open "to the trade only."

This event offers a unique opportunity to see the remodeled former Beatrice Foods cold storage warehouse, which was built in three stages beginning in 1903. Various construction techniques employed through the years, including the heavy timber work in the oldest section of the building are apparent. The Ice House is remarkable for its exceptional polychrome brickwork, high ceilings, and other vintage details.

In addition to its active involvement in the development of Denver Botanic Gardens through the years, the Garden Club of Denver, founded in 1916, has aided numerous other civic projects besides the present "greening of Denver," some on city property and some for other non-profit organizations in the area.

Natural Gardening in Colorado — II

by Panayoti Kelaidis

A modular garden

Allan and Mary Taylor purchased their house in 1965. It was situated on a corner lot dominated by many trim lawns and a giant, spreading Douglas-fir, *Pseudotsuga menziesii*, that grew atop a long retaining wall largely hidden beneath English ivy. Douglas-fir, ivy and lawns are things of the past now. They have been replaced by a series of gardens—discrete units, separated by fences, walls and walks, each with radically different cultural and aesthetic treatments.

Dr. Taylor has written a detailed account of his experiments with various dryland plants in recent issues of *The Green Thumb* but did not elaborate on the garden in which he experimented with most of these plants. In the northwest corner of the lot, bordering the sidewalk and the alley was a stretch of lawn that was a nuisance to maintain. Nostalgia for the dramatic, rocky landscape of his growing-up years on the western slope and a serious interest in tropical cacti inspired the thought of building a natural garden in which to grow their hardy

counterparts. What better place than the far reach of his property that was so hard to keep watered?

The dryland garden was built slowly and deliberately, over a period of almost 15 years. Shapely, interestingly mottled sandstone of the Fountain Formation was placed with meticulous care to imitate the sort of sandstone boulder fields one occasionally encounters in canyon country. Each sandstone boulder—deep purple-red, banded with streaks of white and tan—is almost gaudy in coloration. Somehow, by combining them artistically, interplanting them with silver and green leaved plants, the garden really does look like a piece of sagebrush-west transplanted into the city.

Much of the success of this garden lies in its integrity: some 50 by 25 feet in extent, it is composed of just one kind of rock, and is restricted to native, dryland plants of the American West.

In contrast is a sunken patio nearby, along the north side of the house. Almost 5 feet of earth were removed to create the open space bordered by timbered retaining walls filled with a variety of rhododendrons and azaleas. Perhaps the most dramatic plant here is *Rhododendron metternichii* var. *yakusimanum*, the Yaku Island rhododendron noted for its tight habit and leathery leaves. The specimen is over 10 years old, a furry mound of indumentum much of the early year.

Panayoti Kelaidis, curator of the Rock Alpine Garden at Denver Botanic Gardens and an avid and accomplished plantsman since his early youth, presents here three more outstanding naturalistic gardens in the Denver area. Featured in *The Green Thumb*, spring 1986, were Paul and Mary Maslin's garden in Boulder and Bernice and J. V. Petersen's Colorado garden in Littleton.



Native herbaceous perennials are combined with succulents in the dryland garden.



Mottled red and white sandstone boulders contrast with the silver and green of the succulents growing among them.



Thriving on only the natural rainfall of the area, a dryland garden provides year round interest in foliage texture as well as summer blooms.



88 Aspens, rocks and alpinas create the feeling of a mountain glade in a city garden.

Wooden steps lead to yet another patio to the west, to the back yard lawn and vegetable garden, and to the oldest garden in the yard, an alpine garden that crowns the retaining wall and stretches around the front steps. Aspens and unusual maples help provide a bit of shade in this garden built of lichen-covered granite boulders and interplanted with dwarf conifers and a variety of alpine plants. One portion is reserved for Mediterranean bulbs: tulips, narcissi, crocuses and even the difficult Mediterranean iris, *Gynandiris sisyrinchium*, that has bloomed repeatedly here.

Across the steps from the alpine garden, a small patch of woodland garden grows under a flowering dogwood tree, *Cornus florida*. Masses of holly grape and manzanita carpet the ground beneath the dogwood, and hardy cyclamens bloom prodigally every fall. *Cyclamen hederifolium* appears to be the only reliably hardy species of cyclamen in Colorado, and one plant here is surely over 10 years old.

Descending from these natural gardens on the top of the retaining wall, a large perennial border stretches on the east and much of the north part of the garden facing the street. The neatly mortared wall provides a fine backdrop for Siberian and bearded irises, peonies, roses and many other showy flowers. Perhaps the most dramatic and unusual elements of this border—at least for Colorado—are the large, spectacular azaleas underplanted with a dwarf manzanita, *Arctostaphylos nevadensis* var. *coloradoensis*, that blooms very early in spring, this year opening its first flowers in January. It resembles a robust kinnikinnick, but grows much more thickly, thus suppressing weeds. In summer white bell-like flowers give way to showy berries against lustrous evergreen leaves.

The azaleas are *Rhododendron japonicum*, perhaps the most heat tolerant and reliable species for our climate. They bloom luxuriantly every year in full sun with little extra attention or care. Soil in Boulder is acid, and this spot is protected from the full blast of winter winds. Also

much humus was incorporated in the early years of this garden. With care and study one can often find a spot in local gardens where such exotic plants can be accommodated.

The most recent garden to be developed lies between the perennial border and the dryland garden to the west. It once was a grove of lilacs, and before that a bedded planting of tall bearded irises. Taylor mounded soil (excavated from the patio area beyond) against the retaining wall, planted one of the northernmost piñon pines (rescued from mining operations at Owl Creek) and has slowly been adding a variety of shrubs and dwarf trees emanating from the Southwest and southern Europe. Many are dwarf oaks and broadleaf evergreens which are at such a premium in our steppe climate. It resembles a sort of chaparral, and that indeed was his goal.

For almost 10 years Dr. Taylor has collaborated with the grounds department at the University of Colorado at Boulder to introduce there unusual and interesting trees. He helps purchase unusual trees, finds sources for others, and has donated many rare specimens that he has often grown himself. Among these are true cedars, hemlocks and true cypresses. Many trees on the campus are unique in the entire Rocky Mountain region. One of his greatest contributions locally has been in sharing seeds, plants and knowledge with Denver Botanic Gardens.

Taylor's garden consists of six or seven discrete entities that range from formal vegetable garden and hybrid tea roses to rhododendron beds and natural rock gardens. His special interests range from penstemons and succulents to sequoias and magnolias. Gardening may be his avocation; yet he has attained extensive knowledge and experience, and achieved an excellence that equals the professional.

Garden with a view



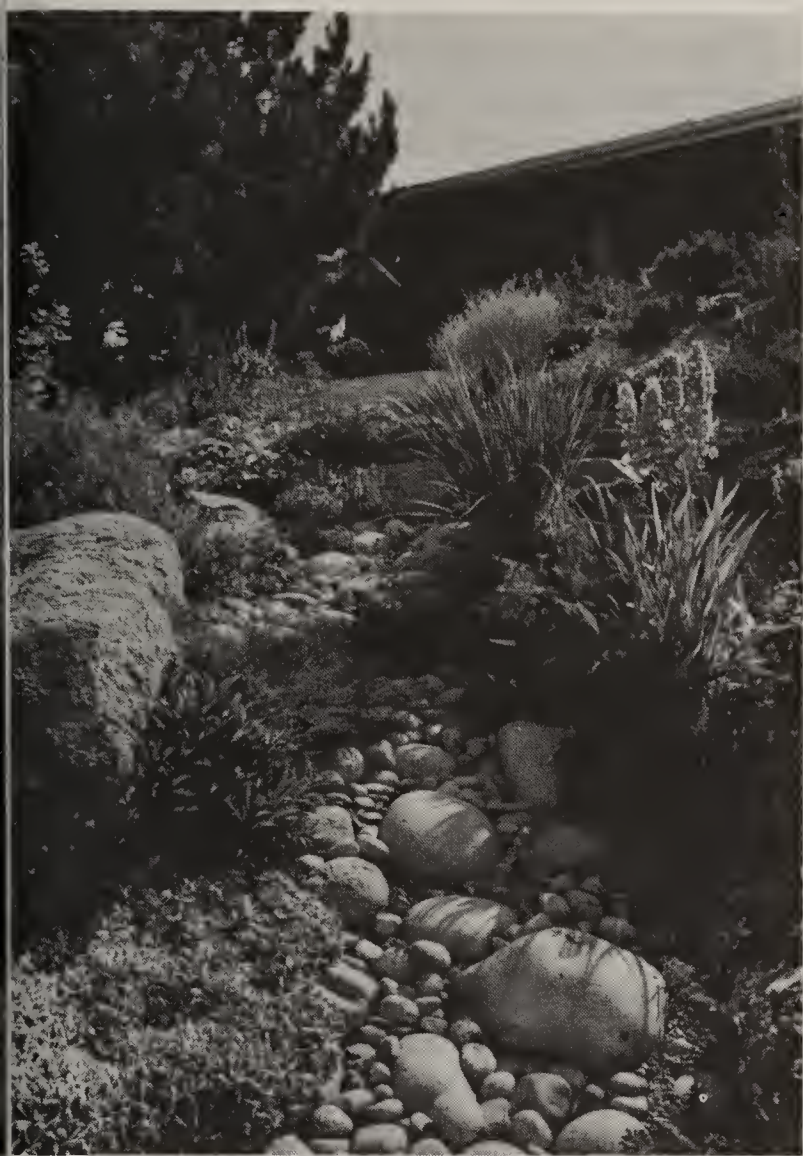
Naturalistic rock garden on steep bank below the deck.

Perched on the highest ridge in Littleton, Bill and Sandy Snyder's new home presented an unobstructed view of most of the Front Range, and Pikes Peak seemed only a short distance away. But the yard—an acre of short, wispy bluegrass and not much else—was discouraging. The few trees on the property showed damage from the disastrous winter of 1969. From the beginning, both Snyders collaborated on planning the garden; but Sandy took the initiative in developing the flower beds which now make this one of the showiest gardens in the region.

Like every plantsman's garden, the Snyder garden contains a multiplicity of beds and garden styles. Some of the first beds developed were along the periphery to mask unsightly fences and screen neighboring yards. A long and undulating perennial border stretches along the western edge of the property, becoming a combined shrub, bulb and groundcover garden bordering the street on the north.

In the perennial border are mass plantings of many standard perennials: vigorous crown imperials, *Fritillaria imperialis*, and hundreds of bulbs to celebrate spring, a constant progression of composites and conventional perennials in summer months, and giant grasses such as *Miscanthus* to add interest in the late fall and winter.

The shrub border is carpeted with sweeps of ground covers, such as variegated ajuga, and mulched areas thickly interplanted with daffodils and tulips. Four upright star magnolias, *Magnolia x loebneri*, form street tree plantings along the north. Other aristocratic shrubs that have gradually spread to cover large areas are colorful brooms including Kew broom, *Cytisus x kewensis*, and winged broom, *Chamaespartium sagittale*, vigorous manzanitas and a number of Somerset daphnes, *Daphne x burkwoodii* 'Somerset.' At the northeast corner the shrub border becomes more formal;



A dry stream bed provides access to view the rock plants from the deck through the rock garden.



A south-facing bank filled with succulents and other heat-loving perennials.

Burkwood viburnums, *Viburnum burkwoodii*, screen neighboring yards and add backdrop to a large planting of hardy hollies of the 'Blue Prince' and 'Blue Princess' series, *Ilex x meserveae*.

The only other bed to the north lies directly in the shadow of the house, a classic site for woodland plants. The native soil was excavated to a depth of 5 inches and replaced with a porous, acid, peaty soil. Several dozen dwarf azaleas and rhododendrons are interplanted with unusual trilliums, hepaticas, evergreen wild gingers and double flowered blood-roots. This garden forms a fine counterpoint to the sunnier gardens to the south of the house.

Every serious gardener must have a work area, and in the Snyder garden this is located east of the house. A prefabricated utility building tucked here stores tools and equipment. A series of sand beds used for propagation extend southward and are delimited by railroad ties. This "railroad tie" garden is versatile. Some small square beds are used for transplants, others are filled with strawberries or other vegetables, some contain plants "in transit" or seedlings. The entire work area is always clean and trim, and interesting to linger over. This garden has been profitable as well, for admiring neighbors and even passers-by have been delighted to purchase starts of the showy plants that fill the garden.

Next to the house facing the railroad tie garden is a bed of succulents. Here are several hardy agaves pupping vigorously and gradually growing larger, promising one day to produce their giant flower stalks. The succulent Greek spurge, *Euphorbia myrsinites*, has one bed largely to itself, since it spreads readily by seed. It can be tolerated here surrounded by paths and patio. In spring, it is a sea of lovely gray, green and yellow. Growing along this hot, south-facing slope are several vigorous cacti including vicious, but interesting, rat-tail cactus, *Opuntia whipplei*.



Euphorbia myrsinites held in check by walls and walkway.

Across the path from this desert garden is another large bed filled with unusual dwarf shrubs and perennials. Among them are more Somerset daphnes including a variegated form, and large, showy mounds of *Daphne cneorum*—intensely fragrant in early spring.

Much of the southeast portion of the Snyder property was an extensive vegetable garden too large and time-consuming for their needs. Intrigued with the use of buffalo grass, *Buchloe dactyloides*, at Denver Botanic Gardens, the Snyders decided it would be a good alternative in this suburb with its exorbitant water rates. The greatest drawback to such lawns is the month or so in spring when buffalo grass remains dormant after bluegrass turns bright emerald.

Why not plant bulbs in the buffalo grass? These are most active when the grass is not, and the grass in turn will help take excess water from the dormant bulbs in summer. Two thousand bulbs of various species, crocus, iris, tulips—even snowdrops and tiny daffodils—were planted in the fall of 1984. The following spring these all bloomed vigorously, and many produced seed. Thus far in 1986, most of the bulbs appear to have increased significantly—a sign that this may be a fine way of growing the minor bulbs in other sunny gardens in this region.

The bulbs are grown in thick colonies—often 100 to 200 of a kind together. These were planted in drifts, naturalistically, and appear to have grown there for decades rather than only two years. The bulbs bloom in waves: earliest crocuses and snowdrops in February and early March, reticulate irises from late February throughout March. April is the month when tulips take over: the glowing purple-magenta of *Tulipa humilis* 'Pulchella Violacea' and the white-tipped yellow of *Tulipa tarda* which in turn are succeeded by the small-flowered, but vivid, *Tulipa linifolia*.

It will be interesting to see how seedlings will distribute themselves through this garden, and if hybrids might appear between some of the more closely related plants. Lawn is no longer a somewhat inanimate and passive surface but here it has become a true garden, an aesthetically complicated entity.

For years a patio extended from the west of the Snyder house, shored up from the garden far below by a tall, steep rock wall. So tall, so steep that after one spring of especially torrential rains the entire wall collapsed. The original patio was never really large enough to entertain outside, so the Snyders decided to redesign the whole area. A larger, curved patio was planned, along with a rock garden to shore it up from the surrounding garden.

Many truckloads of soil had to be brought in to create a proper slope, a path was designed and several large boulders of different sizes were selected for the site. Each of these was photographed, and their placement in the new garden practiced with the photographs on a design done to scale.

Finally, the rocks were brought on a large truck and placed with a crane in their specified locations. Large rockless areas extending between the boulders are intended to mimic the scree slopes one finds frequently in the Rockies. The entire garden has been mulched with pea gravel to enhance the feeling of scree. Several hundred kinds of tiny

bulbs and small herbaceous plants and shrubs now occupy the broad curve of this rock garden. On the hottest, south-facing slope a small area of cactus and succulents includes some of the smallest and choicest natives.

Penstemon teucrioides, the brilliant blue mat-former from the southern mountain parks of Colorado, forms wide mats and cushions on this bank. Tight little buns of rupture-wort, *Herniaria glabra*, pieced with bulbs in spring grow alongside many other tiny cushion plants; Spanish sandwort, *Arenaria tetraquetra*, and New Zealand scab plants, *Raoulia australis*, are some of the choicest. The steep scree slopes are a perfect background upon which to grow these mounds and cushions, which can spread their skirts widely on the surface of the gravel unencumbered by other plants.

At its northern edge, in the shadow of a large Austrian pine, the rock garden takes on a woodland flavor with many cool-soil plants thriving in a peaty bed mulched with wood chips and pine needles. Daphnes and California iris, *Iris innominata* and *I. douglasiana*, grow especially well under these conditions.

This complicated garden is constantly evolving and improving. It not only contains an exceptional collection of unusual herbaceous plants, but more and more rare trees and interesting shrubs. A young tulip tree, *Liriodendron tulipifera*, in the middle of one lawn, and an incense cedar, *Libocedrus decurrens*, nearer the house have survived several years now, and are beginning to flourish.

Plants are constantly shifted in this garden: Sandy is not content with merely putting a plant some place because she *thinks* it should grow there. What matters most is that the plant must grow to perfection and look good in combination with its neighbors. This is a process that cannot take place on paper, but must be proven on the battleground of the garden. One by one each plant that thrives particularly in this garden seems to find its proper place, and a garden of unusual beauty and drama is emerging.



Blue fescue contrasts with dark-leaved aguja ground cover in low maintenance area.



Rhododendrons and woodland wild flowers thrive in the shade north of the house.

A country garden



The curve of native short grass prairie extends to the garden at the front of the house.

One motivation for Coloradoans who move to the country is to avoid the drudgery of gardening. When the meadows and forests around are filled with flowers that natural gardeners struggle to grow in the city, why bother? Robert and Anette Heapes moved to a hilly, sparsely populated area near Parker in 1972. Not only were there children to raise, but weekends were filled with skiing in winter and hiking in summer.

So rich in flowers were the meadows surrounding Heapes' home that he began photographing them and learning their names. He has identified 185 different kinds of native plants on his property—all persisting with no effort on his part. Six species of penstemons alone occur naturally here: *Penstemon angustifolius* and *P. albidus*, both typical of the Great Plains; *P. virens* and *P. secundiflorus* usually restricted to the foothills; *P. gracilis* local in occurrence from New Mexico throughout the Central

States and upper Midwest; and *P. virgatus* var. *asa-grayi*, the last to bloom, found from the plains to the montane zone in Colorado. The 10 acres of Heapes' land is mixed ponderosa pine and shortgrass prairie. The one thing missing was a rocky outcrop. An area along the driveway near the house had been disturbed during construction and had always invited cultivation. What better place for creating the missing feature?

In the summer of 1984 tons of rock were placed along the patio stretching the entire length of the north side of the house, and outcrops were placed to the southeast as well. A lichen-covered sandstone similar to that in outcrops nearby was used. The philosophy was to create a natural garden using native and natural-appearing wildflowers that would have year around appeal of foliage as well as showy flowers for much of the spring before native meadows came into full bloom.

To obtain the large number of plants needed for such an ambitious venture,



A young grove of aspens casts shade for a woodland rock garden.

Heapes constructed cold frames to grow seedlings and scoured local nurseries for the best plants. He read widely in rock garden literature to find out what to avoid, and volunteered in the propagation and rock garden areas at Denver Botanic Gardens to benefit from their experience.

In barely a year and a half he put together a tremendous collection of choice alpine plants that have already spread to cover most of the thousand or more square feet of garden he created. So natural is his rock garden construction that most recent visitors assume the outcrops were always there and the house simply built to take advantage of them.

The naturalistic style of this garden blends harmoniously with the surrounding fields and forests. There is an effortless transition between the untended meadows and the carefully planted gardens. The native plants show little urge to expand into the rock gardens proper, nor do the rock garden cushions show any tendency to become weeds. Heapes has been careful to grow mostly choice, slow growing plants in the rock gardens proper. A wide spectrum of creeping phloxes and numerous kinds of penstemons are especially noteworthy, but literally hundreds of unusual alpine plants are growing rapidly in the virgin soil, some forming large cushions in a surprisingly short period of time.

The various mats and mounds of alpine plants bloom for a long season. In the mild winter of 1985-1986 blossoms could be found on one or another plant any time the snow melted. What has delighted the Heapes most about their new garden, however, has been the way it enhances the patio areas. Certainly, the woods and meadows around their home were always lovely and interesting. But somehow, the new plantings are so colorful, dramatic and appealing that they find themselves having breakfast outside, and sometimes even lunch and dinner, when the weather is pleasant.



The mats and mounds of alpines are decorative even when not in bloom.



Small phlox, *Phlox mesuleuca*, framed in crevice of rock.

Garden visitors from as far away as Britain and both coasts have come to visit and see this remarkable young garden. This summer, the Heapes hosted the annual meeting of the American Penstemon Society in their garden, and the local chapter of the American Rock Garden Society will hold its fall plant sale there. A lovely garden attracts guests as surely as its flowers attract a host of interesting pollinators.

In many ways this country garden represents the classic ideal of natural gardens. Hardly any neighbors are visible from the garden, only wild meadows and woodlands in all directions. Just as rock outcrops in nature seem to harbor an especially rich assemblage of flowers, so too do the seemingly effortless rock gardens around the Heapes' home seem to be an intensification of the surrounding landscape. When the annuals in the planter boxes are devastated by hailstorms or untimely frosts, the hard cushions in the rock gardens seem unfazed. These are the plants nature selected to live in variable climates. They look especially vigorous and healthy in their new home, in a country garden.



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Denver Botanic Gardens

Conservatory Guidebook

Boettcher Memorial Center





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To Our Visitors:

Welcome. This guide has been prepared to add to your enjoyment and knowledge of some of the more important plants of Boettcher Memorial Conservatory. You will find information about their habitat, history and usefulness to animals or mankind.

An alphabetical list (with both common and scientific names) is included in the back of this booklet. This is not a complete inventory of the species growing here; if you have questions about unlisted plants, please ask our staff or consult the Helen Fowler Library.

Let us draw your attention to the wonderful variety of plants: their shapes, colors and textures. Whether the sinuously draped buttress roots of the rubber plant, the dark stems of the black bamboo or the horny-hard spines of the golden barrel cactus, we hope that, as you learn about them, you also take time to delight.

Please, all our visitors, including photographers and artists: Remain on the gravel pathways. Help preserve our plants for the enjoyment of the many visitors who will follow you.
Thank you.

Conservatory hours are 9:00 a.m. – 4:45 p.m. daily, but closed Christmas and New Year's Days. Free guided tours for groups can be arranged by calling our Education Department at 575-3751, ext. 20.

Boettcher Memorial Conservatory

The challenge of housing a lush garden of tropical and subtropical plants here in our arid High Plains environment demands a building of exacting design and construction. Boettcher Conservatory of Denver Botanic Gardens was conceived and built to meet that challenge, beautifully.

Its gracefully interlacing arches rise 50 feet above the garden floor, supported by caissons that penetrate the earth to a depth of 25 feet. During construction these reinforced concrete ribs were poured in place into plywood forms supported by a massive wooden framework.

Plexiglas glazing shelters the 11,500 square feet of garden defined by the arches. Three hundred fifty quarter-inch thick, pyramid-shaped acrylic panes were used, especially designed to bear extra weight and to gather condensation and channel it outside.

Extensive facilities for controlling the Conservatory interior environment include three large gas-fired boilers capable of switching to oil burning during supply limitation emergencies. These heat with low pressure steam distributed through finned pipes located around the perimeter of the building. During warmer days, the plants are cooled by evaporation as outside air is drawn through wet, porous pads. The tempered air warmed or cooled and humidified, is constantly circulated by large fans.

Along with the gift shop to the east and two of the working greenhouses to the west, Boettcher Conservatory was completed in 1965. It was joined in 1971 by the Boettcher Memorial Center, which includes the Helen Fowler Library, John C. Mitchell II Hall (exhibition and lecture auditorium) and the Ida Quentin Mitchell Lobby Court in which are presented seasonally changing ornamental and educational floral displays. Four more greenhouses (including one devoted solely to plant propagation) were added in 1977 increasing the total growing area under glass in support of the Conservatory, the lobby and the outside grounds displays to 10,000 square feet.

In 1981 a new building matching the architectural style of Boettcher Conservatory was attached to the west end of the Conservatory for the purpose of featuring the two largest tropical collections of the Gardens, the bromeliads and the orchids. Marnie's Pavilion is a bilevel structure: Floral displays of orchids and bromeliads delight the eye on the top floor, the collections are cared for on the lower floor where, because of the unique design of the building, they remain visible to visitors above. (This lower level is, as are all the working greenhouses, open to the public only in groups with prior arrangement.)

Erected on a nearly empty 20-acre plot of urban prairie reclaimed from an abandoned cemetery, Boettcher Conservatory has become the centerpiece of an expanding educational center providing citizens and visitors of the High Plains and Rocky Mountains a rare tropical garden experience.

How to read our labels:

The plants mentioned in this booklet are identified in our Conservatory by large white-on-blue labels. These labels convey the following information:

1. **The Number-Letter combination** on the left side of the label corresponds to the Number-Letter designation in front of each plant's name in this guide. The number represents the plant's numerical order in this tour and the letter, either L or R, signifies whether the plant grows on the Left or Right side of the path.

2. **The Scientific Name**, at the top of the label, is the one by which the plant is known officially throughout the world. The first word is the genus name, the second is the species epithet. Sometimes, a varietal name is included after the species name. (Note: In this booklet the *scientific name* is italicized and the name of the author for each plant or the abbreviation for that name, not italicized, directly follows it. The varietal name is preceded by the abbreviation "var." for "variety" or "cv." which stands for "cultivated variety" or "cultivar").

3. **The Common Name**, though often descriptive and handy to use, is definitely unofficial and is often not the same from one culture to another or from person to person. In fact, you may very well disagree with our choices. This is why the scientific name is necessary to identify the plant with certainty.

4. **The Family Name**, at the bottom of the label, signifies a larger group of closely related plants to which the genus belongs. By noticing which plants belong to the same family, you will begin to appreciate some interesting similarities — or surprising differences.

Example:

Scientific Name	FICUS RELIGIOSA
Guidebook Order	29
Common Name	SACRED BO TREE
Left or Right Side	L
Family	MORACEAE



Following the directions in this booklet, you can explore Boettcher Memorial Conservatory on your own self-guided tour. It begins just inside the doors entering from the west end of the lobby.

With your back to the doors, face westward up the main pathway to find the first plant described. It will be identified with a large white-on-blue label.

1-L

Hong Kong Orchid Tree

Bauhinia blakeana

S. T. Dunn

China

Leguminosae

(alt: Fabaceae)

The orchid tree is prized as an ornamental throughout the tropics. In the United States this small tree is restricted to the warmer parts of Florida, California and the Gulf states, where it blooms from December to April and it is showiest before its curious leaves have emerged for the season.

These unusual bilobed, or "twin," leaves gave rise to the genus name: It was named in honor of two brothers John and Caspar Bauhin, both early botanists, who were mistakenly thought to be twins by the scientists who first described the plant. Its common name refers to its large orchidlike blossoms.

Bauhinia blakeana
Hong Kong Orchid Tree



Vines and Other Climbers

The word "vines" has traditionally referred to the grape (*Vitis* species) but horticulturally it also means any erect plant whose stem is naturally too weak to support itself growing upright. Whether climber or trailer, it may support itself using a variety of ingenious methods:

English ivy (*Hedera helix*) and philodendrons, for example, hold fast by means of aerial roots or rootlike extensions with clinging surfaces.

The passionflower vines (*Passiflora* species) and grapes employ modified leaves or leaf extensions called tendrils. These growths imperceptibly but constantly rotate, waving in the air. When they touch a likely support, they coil around the object, growing larger and stronger, until they hold it fast.

Some plants climb by means of their twining growing tips which perform similarly to tendrils. Examples of these are *Clerodendrum speciosissimum* and *Thunbergia grandiflora*. The rangoon creeper (*Quisqualis indica*) employs both twining and the production of heavy thorns.

Other climbing plants are hardly more than over-vigorous shrubs, having no special clasping ability, merely leaning on other objects for support. The bougainvilleas (*Bougainvillea* species) are of this type, but to help hold themselves up after they've grown long and floppy, they develop hooked thorns to catch against possible supports and keep their stems from falling.

Some tropical vines become enormous as they grow and spread, developing thick woody stems; they are then called lianas."

2-R

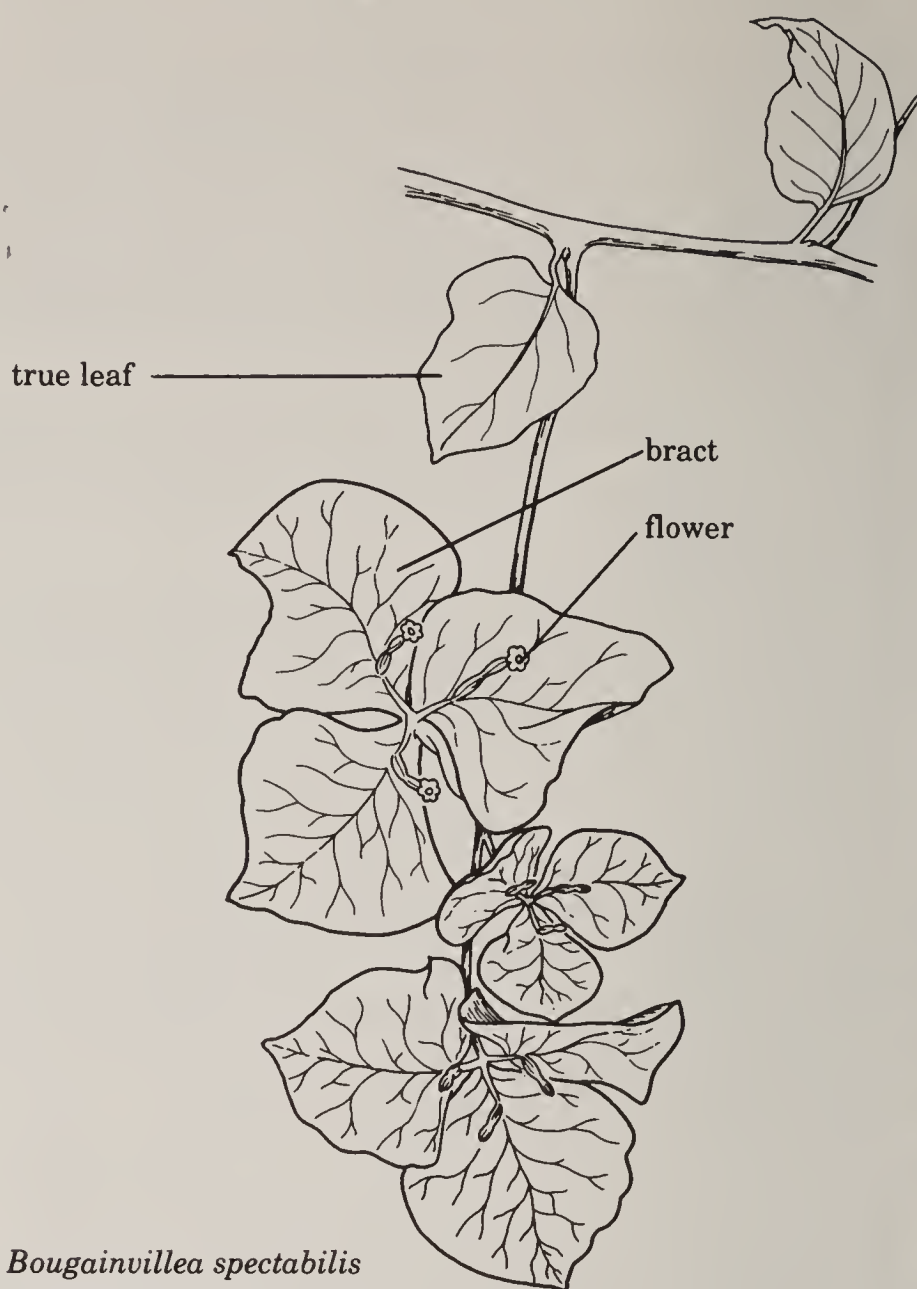
Paper Flower (Bougainvillea)

Bougainvillea spectabilis
Willd. cv. Panama Pink
Brazil
Nyctaginaceae

The brilliant "flowers" of this shrubby vine are as interesting as they are beautiful, for they are not what they appear to be. The actual flowers are slender, white and tubular. There are three of them nestled within the three brightly-hued bracts (in reality, modified leaves) which, because of their size and coloring, seem to make up a flower.

Named after Louis de Bougainville, who in 1769 became the first Frenchman to circumnavigate the world, these Brazilian plants have remained favorites for greenhouses and tropical landscapes since their introduction into horticulture sometime before 1820.

Illustration on next page



Bougainvillea spectabilis
cv. Panama Pink
Paper Flower

3-L

Banana

Musa × paradisiaca L.

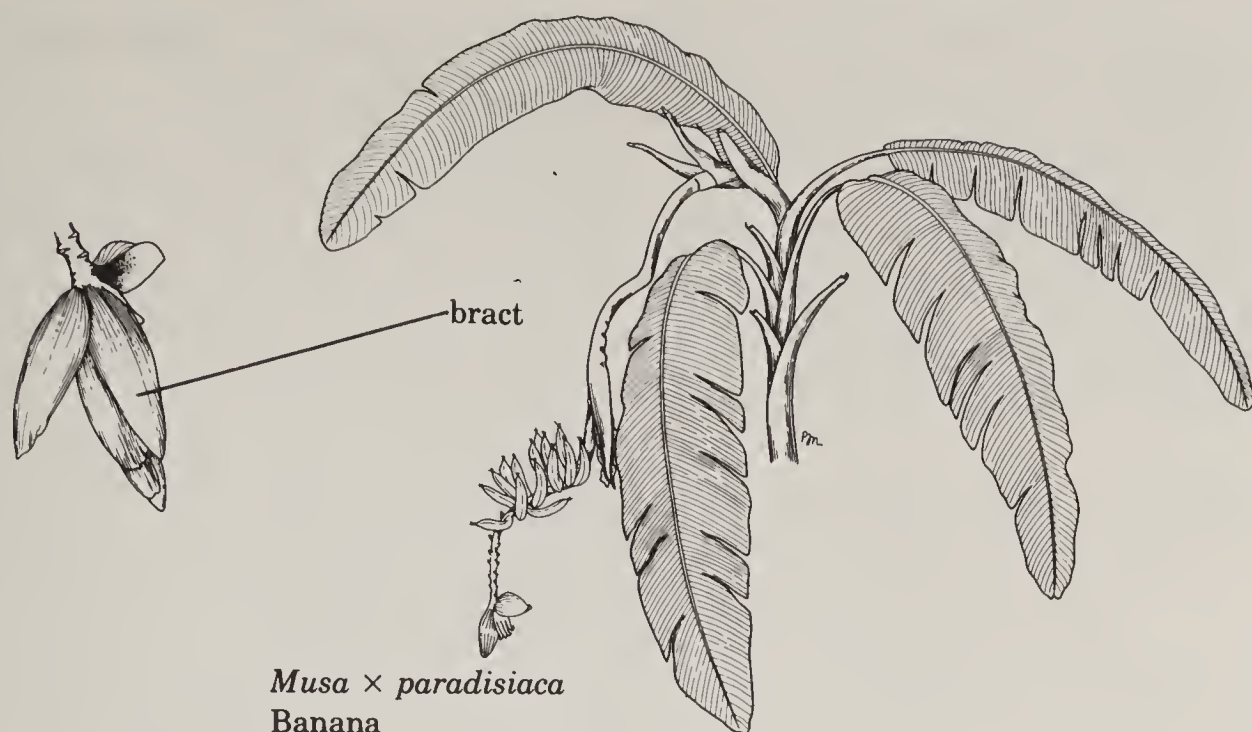
India

Musaceae

Although the banana plant superficially resembles a tree, it is, botanically, a giant herb. Its non-woody "trunk" is actually the interclasping, flattened petioles, or "stems," of its leaves arranged similarly to a bunch of celery. These petioles arise from the true stem called a rhizome, which lies underground.

After the plant has produced its leaves, the inflorescence, or flower stalk, forces its way up through their midst. One by one, the purplish bracts which overlap around the stalk roll back to expose half-whorls of small, yellow tubular flowers. The upper groups of flowers become "hands" of banana fruits.

As a food crop the banana is enormously important. Huge plantation and shipping companies have been established and they wield considerable economic and political power in tropical countries where the fruit is grown. Two basic kinds of bananas, now thought to be of common origin, are grown: The sweet banana, meant to be eaten raw, is shipped mainly to markets in Europe and North America; the drier *platano*, or plantain, eaten unripe as a cooked starchy food, is the favorite of tropical residents.



The Nightshade Family: Solanaceae

No other family of dicots (plants whose first seedling leaves appear as a pair and whose subsequent leaves are characterized by a network of veins) can match the scope of this family for foods, medicinal (and poisonous) drugs and horticultural ornamentals.

Floral characteristics of the Solanaceae include a five-parted regular corolla that may be tubular or funnel-shaped and five stamens arising from the throat of the corolla.

Its culinary contributions include the single most important vegetable in the world, the "Irish" potato (*Solanum tuberosum*) from the high Incan Andes; the tomato (*Lycopersicon esculentum*), first cultivated in Mexico; the sweet pepper (*Capsicum annuum*) and the more pungent chili pepper (*C. frutescens*), whose innumerable varieties sprang originally from tropical Ecuador and Peru; and the eggplant (*Solanum melongena*) from India.

Plants that have contributed drugs and narcotics are *Atropa belladonna* from Europe, used to relieve pain (It was also used by women to dilate the pupils of their eyes, in the dangerous belief that it made them more attractive.); the many *Delphinium* species from around the world, which produce hallucinatory and hypnotic effects; *Mandragora officinarum*, the mandrake from Mediterranean Europe, whose reputed aphrodisiac and sexual-healing properties earned it superstitious reverence from the Dark Ages to Elizabethan times; and, one of the most violently poisonous plants of all, *Nicotiana tabacum*, tobacco. A single drop of purified nicotine, applied to the human skin, is fatal; this alkaloid is also absorbed into the body through the tissues of the mouth and

lungs, yet consumers ingest billions of dollars worth per year, making it an important subtropical crop.

Of the 2,000 species in the family, many are attractive; some others are weeds. In our Conservatory, the prettiest is the yesterday-today-and-tomorrow (*Brunfelsia calycina*) and in the outdoor gardens the star is the common hybrid petunia (*Petunia* × *hybrida*).



Solanum dulcamara
Deadly Nightshade

4-L

Angel's Trumpet
Brugmansia suaveolens
Bercht. & Presl
(*Datura suaveolens*,
Hook. f.)
Brazil
Solanaceae

The trumpet-shaped blossoms of this small tree are pearly white and intensely fragrant at night, two frequent characteristics of plants pollinated by nocturnal moths. The long-stalked flowers can develop to a length of more than one foot and a large specimen in full bloom is a spectacular sight.

All parts of the plant are dangerously poisonous to human beings although it is widely cultivated and naturalized in many parts of the tropics at low elevations.

5-R

Tapioca (Cassava)
(**Manioc**)
Manihot esculenta Crantz
Brazil
Euphorbiaceae

Even though the skin which covers its large tuberous roots is poisonous, primitive people devised methods of skinning this root, washing the chopped flesh and heating it to cause its abundant starch to coagulate in an edible paste. A single plant may yield 10 pounds of starch from its roots. Natives who still subsist on it in the tropical lowlands where it is cultivated often suffer from malnutrition because, although it is rich in carbohydrates, tapioca lacks necessary vitamins and minerals.

Besides being processed into farina and tapioca, the starch is also used in the production of adhesives, cosmetics, textile sizing and paper.

The Spurge Family: Euphorbiaceae

The Christmas poinsettia (*Euphorbia pulcherrima*) from Mexico is by far the best known plant in this family of 7,000 species, most of which have rather insignificant flowers. Some have no petals but have colored bracts or glands to take their place. The large brilliant "flowers" of the poinsettia are, in fact

bracts; the greenish yellow male and female flowers are clustered in the center of the bracts.

All spurges have this separation of pistillate and staminate flowers in common, and nearly all contain a sap of milky latex, but in other ways the plants show amazing diversity. Some are vines, others float in water, many are woody trees or shrubs, some are herbaceous mats and still others, perhaps the most interesting, are cactuslike succulents.

Economically, the most important are the Para rubber trees (*Hevea brasiliensis* and other species) of the Amazon basin, the cassava (*Manihot esculenta*), and the castor oil plant (*Ricinus communis*) whose oil is used in laxatives and as an industrial lubricant. Grown throughout the world for its ornamental palmate foliage, *Ricinus* seeds contain a substance, ricin, which is among the most deadly compounds known. Still other plants of the family contribute a multitude of substances of great medicinal value.

Spurge family plants that brighten our Conservatory with other colorful foliage or floral bracts are the crotons (*Codiaeum variegatum* var. *pictum* cvs.), the match-me-if-you-can (*Acalypha wilkesiana*), the crown of thorns (*Euphorbia milii*) and the scarlet plume (*E. fulgens*). Many also grow outdoors, either as ornamentals or as weeds. The native snow-on-the-mountain (*E. marginata*) is one of the most attractive.



6-R

Coffee

Coffea arabica L.

Africa

Rubiaceae

Originally from the Ethiopian highlands, coffee was introduced to Europe in the 1600s by traders from Arabia where its use as a beverage is supposed to have been discovered in the 15th century. Today consumption of coffee in its African homeland is minimal, although it is cultivated extensively there. Internationally, coffee ranks second as the most valuable commodity, behind petroleum. It has the highest commodity value of all imports to the United States, which consumes over half the world's coffee production.

Coffee "beans" are the seeds that occur in pairs inside the plant's brilliant red berries. They take six to several months to mature. When ripe, the pulp is removed and the beans are dried, shelled, graded and stored to season, then roasted and ground.

7-R

Papaya (Melon Tree)

Carica papaya L.

Tropical America

Caricaceae

The delicious fruit of this South American tree, long popular in the hot tropical lowlands where it grows, is only now becoming commonly available in Northern markets. However, the protein-digesting enzyme papain, extracted from the fruit and other parts of the papaya, has been the major ingredient in meat tenderizers found on grocery shelves for years.

This chemical is also used for clarifying beer and in the manufacture of medicines and cosmetics. A new use for papain is as a cleaner for soft contact lenses; it dissolves the protein coating that accumulates on the surfaces during use.

8-R

Rose of China (Shoe-Black Flower)

Hibiscus rosa-sinensis L.

cv. American Beauty

South China

Malvaceae

The exotic flowers of the hibiscus have made them favorites in tropical and subtropical landscapes the world over. Their wide array of colors is the result of extensive hybridization. Captivated by the bold beauty of the wild single scarlet variety, Hawaiians designate this hibiscus their official flower in 1923.

Although the wilted flowers are sometimes used to brighten the shine of black shoes — hence, one of the common names — hibiscuses are treasured primarily for their ornamental value. Important economic relatives within this family are cotton and okra.

The Palm Family: Palmae (alt: Arecaceae)

Graceful, majestic, elegant — the palms were aptly called the "Princes of the Plant World" by the father of modern botany himself, Carl von Linné. Of all the monocots (plants that produce one seedling leaf and whose subsequent leaves have parallel veins) the palms are by far the most handsome.

In addition, they are also among the most valuable of all plants. The coconut (*Cocos nucifera*) is unchallenged as the most useful, with over 1,000 applications. The date palm (*Phoenix dactylifera*) yields up to 100 pounds of sugary fruit

per year over the century-long life span of each plant. Tolerant of arid climates, it has nourished the civilizations of northern Africa and the Near East for over 5,000 years. The carnauba wax palm (*Copernicia cerifera*) produces a hard natural wax with an extremely high melting point, which is utilized in the manufacture of candles, shoe polish and floor wax. The rattan palms (*Calamus ornatus* and other species) of Malaysia yield their thin vining stems for the construction of furniture and dwellings. Wherever they grow around the tropical and subtropical world, the palms have contributed to the well-being of mankind in innumerable ways.

The flowers of the 2,800 species of palms are small, and are borne in clusters from a spathe-like bract. They vary in only minute ways, making classification difficult. Therefore, botanists often use different characteristics of their leaves to distinguish them. In our Conservatory you may find examples of all three major leaf shapes — feather, fan and fishtail — and note the variations in form that they exhibit.

9-R

Coconut

Cocos nucifera L.
cv. Malayan Dwarf
Pan-Tropics
Palmae
(Alt: Arecaceae)

Coconut palms provide one of the world's largest economic crops. Although its sweet nutmeat is delicious in pies, candies and macaroons, of much greater value is its oil, used in the manufacture of cosmetics and pharmaceuticals. The fresh nutmeat and milk from the coconut provide hundreds of millions of people in the tropics their much needed sustenance. Additionally, the tree provides charcoal, fiber, lumber and thatch.

The cultivar 'Malayan Dwarf' is replacing older types because of its resistance to the "lethal yellows" viral disease that has nearly obliterated the world's crop in recent decades.

10-L

Pepper, Black and White

Piper nigrum L.
Tropical Asia
Piperaceae

The dried fruit of pepper vines is one of the oldest and most important of all spices. Reputedly introduced into Europe by Alexander the Great after his campaign to India, pepper was immediately favored as a condiment, preservative, medicinal ingredient and, later, in the Middle Ages, as a mask for the odors of bad food and unwashed humanity.

The voyages of Vasco de Gama (successful) and Columbus (unsuccessful) were launched to find a reliable sea route for the importation of this and other spices from the East Indies, which were known as the "Spice Islands."

11-L

Queen Sago

Cycas circinalis L.

Tropical Asia

Cycadaceae

Although cycads appear similar to tree ferns and palms they are, in fact, related to neither. Instead they are extremely primitive non-flowering, seed-bearing plants, living fossils that have changed little since their age of prominence 300 million years ago when dinosaurs ruled the animal kingdom.

Cycads are either male or female, each bearing a characteristic cone. The male cones produce pollen and the female cones bear naked ovules that develop into seeds. These naked seeds give their subdivision in plant classification (which includes cycads, the ginkgo and conifers) the name "gymnosperms," which, from the Greek language, means "naked seeds."



Cycas circinalis
Queen Sago

12-L

Whisk Fern

Psilotum nudum (L.)

Beauv.

Tropic, Subtropic, &
southern USA

Psilotaceae

The whisk fern is one of the few living close relatives of the oldest known vascular plant whose fossil has so far been discovered: *Psilophyton*. This ancient ancestor lived during the Devonian Period, also known as the "Age of Fishes," some 350 million years ago, an era which saw the beginning of upright, complex green plant life on land.

During this time, some plants developed intercellular spaces which allowed for the exchange of gases between the inner cells of the plant and the exterior environment. They also developed the capability to transfer water and nutrients to all the cells, becoming independent of their former homes underwater or on the water's surface.

Although allied to true ferns, psilotums are even more primitive, having neither true roots nor leaves. Instead, each plant consists of only a stem: The lower part transports water and the upper part photosynthesizes and bears the reproductive sporangia.



Now turn to your right to leave the main pathway. (You will walk along to the left of the small pond, then circle uphill until you join the main pathway again.)

13-R

Giant Horsetail

Equisetum giganteum L.

Tropical America

Equisetaceae

A weak and rambling plant, this modern-day horsetail from tropical America is a rather poor representative of a once magnificent family. Millions of years ago, during the Carboniferous Period when our Earth was much warmer, horsetails were towering "trees" with branched, leafy crowns. Along with the ferns and club mosses, they formed a major part of the plants that eventually became coal.

Their hollow, jointed stems contain a high percentage of silica, making them somewhat useful as primitive abrasives and giving rise to their other common name, "scouring rushes."

14-R

Traveler's Tree

Ravenala madagascariensis J.F Gmel.

Madagascar

Strelitziaceae

According to popular accounts, a thirsty traveler can always find a drink in a traveler's tree: Where each trough-shaped leaf petiole clasps its trunk, a reservoir is formed that traps rainwater. This story, though the basis for the plant's common name, is plausible only if the traveler is willing to drink what is probably very rancid, infested liquid.

The plant has other uses, however. Not only is it a dramatic tropical landscaping plant when it reaches maturity, but, on the island of Madagascar where it is found, sugar is made from its sap and roofing thatch from its leaves.

The flowers, leaves and fruits are similar to its cousin, the white bird-of-paradise. Its edible seeds are encased in brilliant blue arils (fibrous appendages to the seed coats), which make the dry, opened seed pods strikingly ornamental.

15-R

Screw Pine

Pandanus utilis Bory

Madagascar

Pandanaceae

The strong stilt roots and spiraling ascension of its leaves are two interesting features of the screw pine. The roots help colonize the trees into dense strips along the coastal regions of the tropical Pacific and Indian Oceans. The spiral pattern of its toothed leaves provides its common name and gives a distinctive design to its trunk.

The screw pine yields several useful products: thatching, baskets, mats and hats from its fibrous leaves and starchy food from its large conelike fruits.

A close relative, which inhabits shallow fresh waters the world over, is the common cattail.

The Mulberry Family: Moraceae

This family contains not only the mulberries, but the figs, as well. They share the strange unifying floral characteristic of an aggregation of small unisexual flowers, in a compound arrangement on a disk, stalk or within a hollow receptacle. Most members also have a milky sap.

The white mulberry of China (*Morus alba*), though its fruit is edible, is most famous as the food for silkworms; this small tree supported the major industry of the Orient until the development of synthetic textile fiber earlier in this century.

suddenly reduced the value of silk. The juicier fruits of the black mulberry (*Morus nigra*) and the red mulberry (*M. rubra*) are preferred for eating.

The largest genus of the family is *Ficus* and it is represented in our Conservatory by many species: the biblical "sycamore" tree (*F. sycomorus*), the creeping fig (*F. pumila*), the clown fig (*F. parcellii*), the Indian rubber plant (*F. elastica*) and others.

The ill-fated voyage of H.M.S. *Bounty*, captained by William Bligh, was for the purpose of transporting breadfruit tree seedlings (*Artocarpus altilis*) from Tahiti to the West Indies; the starchy fruit of this tree was to be used to feed slave of that region. The mutinous Fletcher Christian dumped the trees but Bligh returned later to complete his mission. However only slowly did this fruit gain acceptance as a tropical staple. The tree itself is quite beautiful, with large dark green, glossy oaklike lobed leaves.

Outdoors we have a fine stand of another species of this family, the osage orange tree (*Maclura pomifera*). Because of its drought tolerance it was widely planted by settlers of the High Plains as a windbreak, but few, besides this group, remain around Denver today.

16-L

Banyan

Ficus benghalensis L.

India

Moraceae

The English name, banyan, seems to have been given by the British to another *Ficus* species in Persia under which Hindu merchants, known as *banyas*, gathered for business and worship. Ultimately, the name spread within the Empire to include the present tree from the hill forests of India.

The banyan begins life as an epiphyte, a trait common with many members of the genus, which are collectively known as "strangler figs." Dropped by a bird or monkey that has eaten the fruit, its seed germinates on the stem of a palm or other tree during the monsoon season, sending roots downward along the mossy trunk to the ground, at which point the plant becomes independent of its host. Eventually the fast-growing fig strangles its host, which perishes and rot away, leaving the ficus to stand alone.

Under uninhibited tropical conditions the banyan extends additional roots from its branches to earth. These supplement its main trunk to form a "forest" of adventitious roots under a single plant. Thus one tree may spread to cover an area hundreds of feet across.

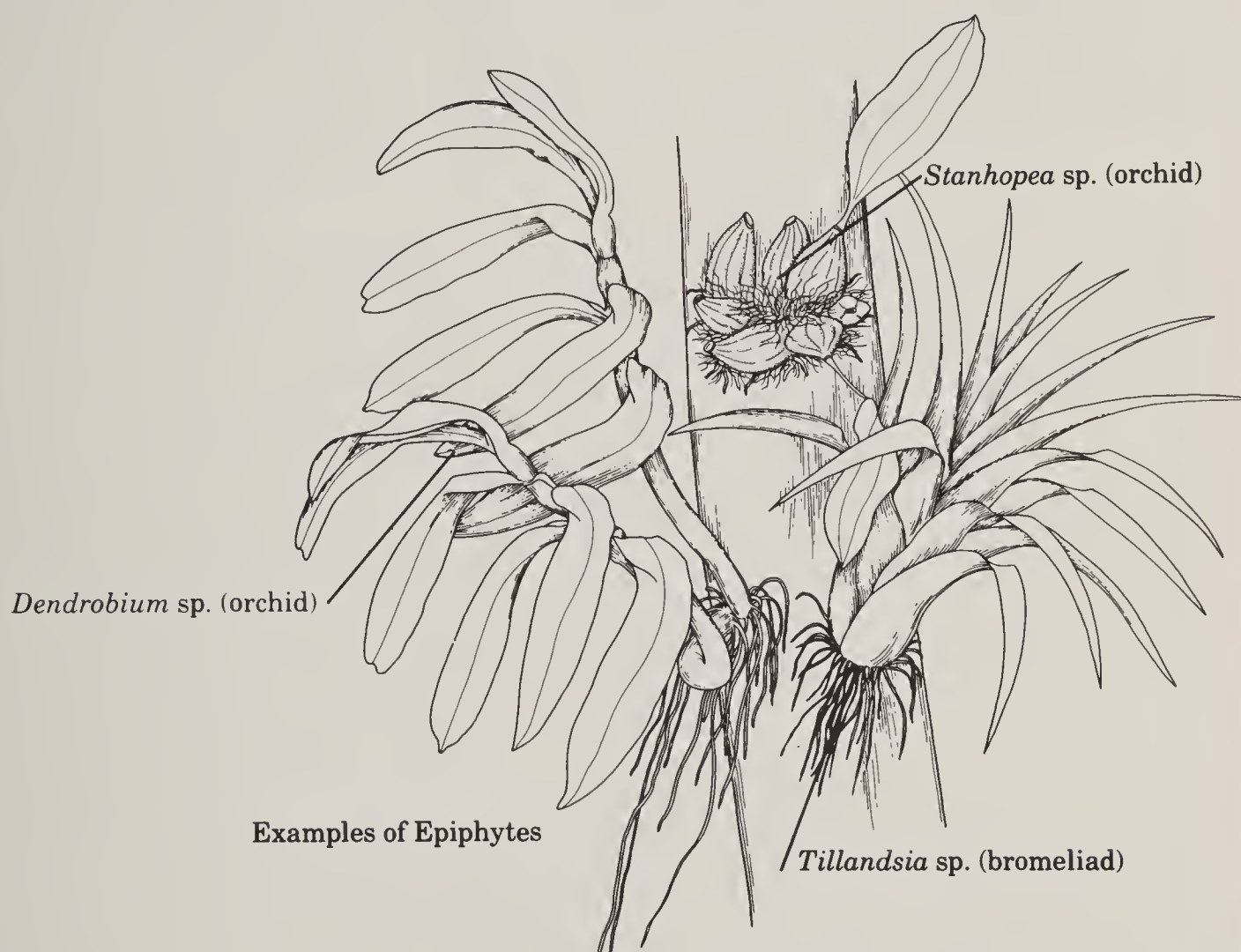
Epiphytes

In climates with a humid atmosphere, especially in the tropics, some plants live upon others, using them as a means of support. They derive no nourishment from their host plants, unlike

parasites, but use them only as a means to attain adequate light and space in often crowded forests. These opportunistic plants are known as epiphytes, a word derived from the Greek *epi* meaning "upon" and *phyton* meaning "plant."

The term does not imply genetic or evolutionary relationships. Among the plants that live this way are examples from many different unrelated families: orchids, bromeliads, ferns, aroids, cacti, peperomias, rhododendrons and others. Tree-perchers of advanced plant families are common in the tropics, but in temperate zones they are more often of the lower plant groups, such as lichens.

Each epiphyte reaches its berth as a seed or spore, carried into a crevice in the host's bark or dropped into the debris on its surface by the wind, a bird or other animal. There it germinates and sends out its roots for clinging, moisture and nourishment.



17-L

Staghorn Fern

Platycerium bifurcatum

(Cav.) C.Chr.

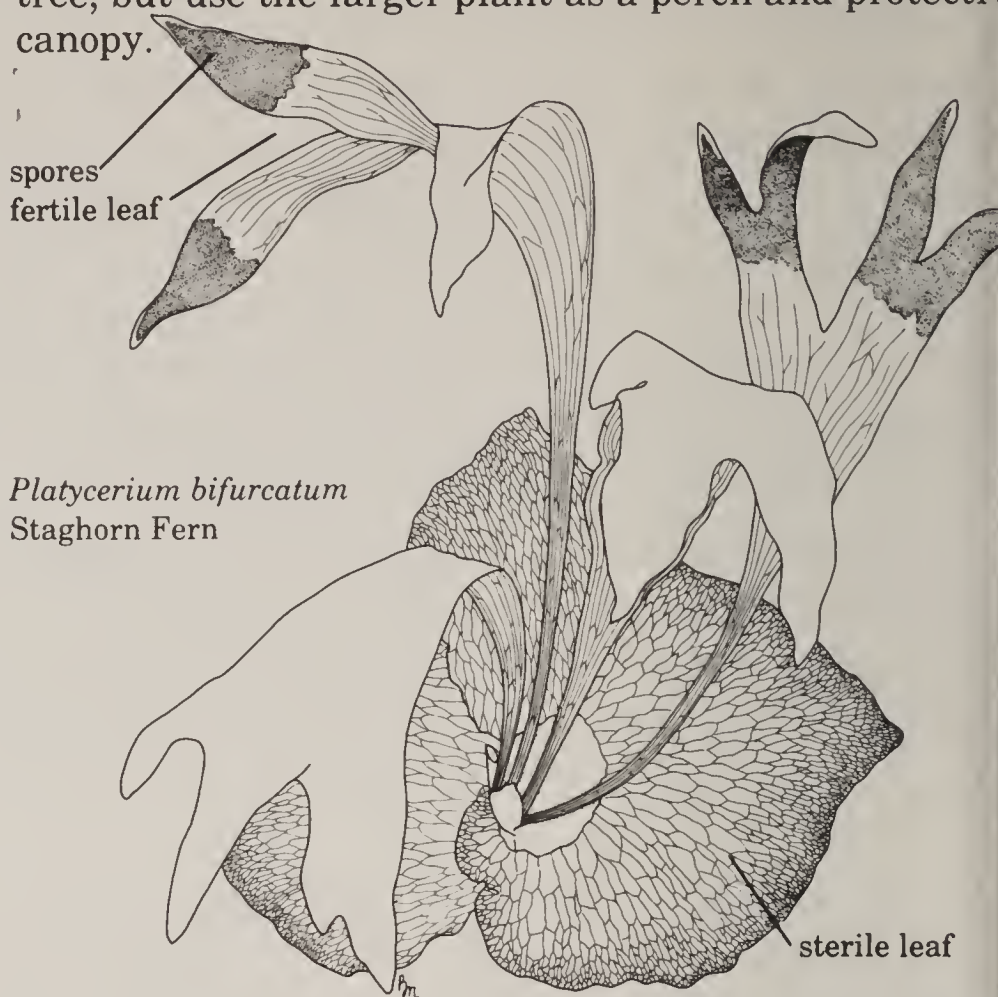
Australia

Polypodiaceae

Casual observers might fail to recognize that this bold, leathery plant is closely related to the feathery, delicate ferns commonly grown in containers and in gardens. However, platyceriums reproduce by means of spores produced on sections of their fertile fronds, exactly as do other ferns.

Actually, staghorns have two types of leaves. The large, antlerlike fronds which arch out from the center of the plant support the reproductive organs. The round, disc-shaped leaves pressed against the host tree (usually stiff and brown with age) serve as catch basins for water and decaying humus for the roots.

As with other epiphytes (and unlike parasites), platyceriums derive no nourishment from their host tree, but use the larger plant as a perch and protective canopy.



Platycerium bifurcatum
Staghorn Fern

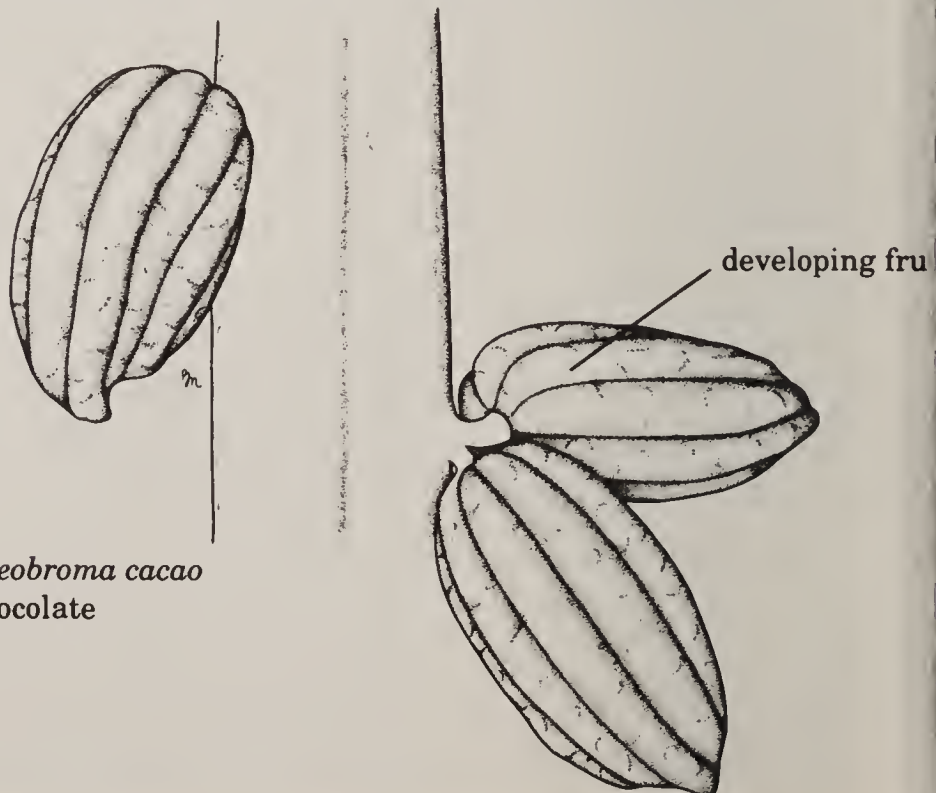
18-R

Chocolate

Theobroma cacao L.
Central America
Sterculiaceae

The passion for chocolate is not new. Chocolate trees were cultivated for their beverage-producing seeds more than 2,000 years ago by natives of Central America whose name for it meant "food of the gods," which, translated into Greek, became *Theobroma*. Considered of divine origin, chocolate seeds were used as currency to pay tribute to the Aztec emperors.

The Spanish were the first to process chocolate in Europe where, by the 17th century, it became a popular beverage. In 1828, Netherlands developed a method of removing most of the fat from chocolate. Their product, the dry powdered "cocoa" marketed in this country, became known as Dutch chocolate.



Theobroma cacao
Chocolate

19-R

Lipstick Tree (Annatto)

Bixa orellana L.

Tropical America

Bixaceae

The seeds and fibers within the burred fruits of the bixa yield an intense red dye. Originally used by the Carib Indians and other peoples of the West Indies and of Central and South America to decorate their bodies, it is still used today in the production of cosmetics, hence its common name.

Foods are also prepared with this coloring, especially cheese, butter, margarine, chocolate and rice. A few bixa seeds added during cooking give a characteristic flavor and orange color to many Caribbean and Brazilian dishes.



Here, continue on the main path up to the hill.

20-L

Bunya-Bunya

Araucaria bidwillii Hook.

Australia

Araucariaceae

In the tropical lowlands of its native Queensland, this attractive tree grows to a height of 140 feet. The female cones may weigh 10 pounds and yield up to 150 two-inch seeds. These are an important food source for the aborigines and, for their use alone, the Australian government has set aside protected areas where the harvest of the trees for wood is carefully restricted.

The bunya-bunya and its relatives, the monkey puzzle tree and Norfolk Island pine, are closely allied to the giant sequoias of the Northern Hemisphere.

21-R

Mahogany

Swietenia mahagoni Jacq.

West Indies

Meliaceae

Many trees have been called mahogany but the true mahoganies are either New World plants of the genus *Swietenia*, including Honduran mahogany, or closely related African trees of the genus *Khaya*, African mahogany. So-called Philippine mahogany is from several entirely different kinds of trees.

The original mahogany is this tree which the Spanish conquistadors discovered in the West Indies. They found its beautiful warm-hued wood to be fine grained, hard and easily polished and in a short time it became the foremost furniture and cabinet wood in the world. It is still highly prized as one of the finest woods used in cabinetry.

The Rue Family: Rutaceae

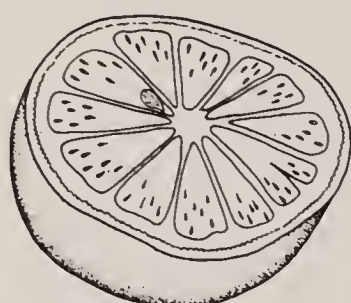
Citrus, with eight small types of trees contributing oils and edible fruits, is by far the most important genus in this family of some 1,500 species. All *Citrus* species originated in India, China or Southeast Asia, though their precise introductions into cultivation have been obscured by time.

Limes (*Citrus aurantifolia*) are a favorite in the tropics for flavoring and fresh juice and are also used to make marmalades, citric acid and lime oil; the sour or Seville oranges (*C. aurantium*) are used in marmalade and in liqueurs, because they're far too sour to eat out of hand; the pummelos, or shaddocks, (*C. grandis*) are also preserved, both flesh and rind, but are delicious fresh as well; lemons (*C. limon*) produce oil,

citric acid and pectin, as well as flavor lemonade and other beverages and foods: citrons (*Citrus medica*) are used as flavoring, especially their candied peels, and contribute to the Jewish ceremonial Feast of the Tabernacles; grapefruits (*C. × paradisi*) are eaten fresh mainly at breakfast; tangerines, or mandarins, (*C. reticulata*) are eaten fresh or canned; and the sweet orange (*C. sinensis*) the most important of all, is eaten fresh and processed into frozen and canned juice.

Related Conservatory plants are the curry bush (*Murraya koenigii*) from India and the kumquat (*Fortunella japonica*) from China and Japan. Members of this family grown outdoors include the gas plant, a perennial border favorite (*Dictamnus albus*), so called because it emits flammable fumes, and rue, the herb of grace, (*Ruta graveolens*).

Often fragrant, the flowers of this family usually have three to five petals, twice that many stamens inserted around a disk, a superior ovary and styles connected together.



Lime



Citrus aurantifolia

22-L

'Moro' Blood Orange

Citrus sinensis (L.)

Osbeck cv. Moro

Rutaceae

Throughout the Mediterranean region, blood oranges are highly esteemed; there they comprise about one-third of all oranges consumed. The 'Moro' variety, of Italian origin, is nearly seedless and its dark ruby fles offers a refreshing citrus flavor with a hint of raspberry.

Here in the United States where more than four million tons of sweet oranges a year are produced, blood oranges are rarely grown except as backyard novelties. However, they have become increasingly popular and are sometimes found in specialty markets.

23-L

Tea Plant

Camellia sinensis (L.)

O. Kuntze

(*Thea sinensis* L.)

China

Theaceae

For beverage use, tea was first domesticated 2,000 to 3,000 years ago in China, and was probably used there even earlier for medicinal use. It was introduced in Europe in the 1600s but by that time coffee had already established its popularity.

Because they were economically involved with the tea growing nations of Southeast Asia, the British eventually chose tea as their favorite brew and now consume more than half the world's production — over 10 pounds per capita. By comparison, the United States

as second largest consumer nation, uses only 0.7 pounds per person. There are some 200 tea bags in a pound of tea.

This handsome shrub is grown in the subtropics and in cooler, higher altitudes of the tropics. The processing of tea leaves is simple: After wilting, they are fermented for a short time to develop flavor, then shredded, dried, and packed, all under extremely sanitary conditions.

The Grass Family: Gramineae (alt: Poaceae)

It is impossible to overestimate the importance of this family. A list of only a few of its food-producing plants will amply demonstrate its immense value: wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), corn (*Zea mays*), rice (*Oryza sativa*), oats (*Avena sativa*), sorghum (*Sorghum bicolor*) and sugarcane (*Saccharum officinarum*).

The roots of civilization itself are entwined with those of a wild Middle Eastern wheat species. Now unknown, it flourished in the humid, temperate climate of plentiful rainfall that followed the last receding ice age. Wandering tribes learned to depend upon this grain and soon found it necessary to settle, at least temporarily, during the brief periods of harvest. Later they found it advantageous to halt their travels to augment the natural germination with additional plantings and then they were faced with devising both methods and places for storage. Eventually, forced to abandon their nomadic ways to remain near their stores, around those natural grain fields they established the first permanent human settlements.

It must have been not long after this momentous development that the various grasses also began yielding alcohol (beers, ales, whiskeys, gin and rum), oils, starches and forage for domesticated beasts. In the Orient, the versatile tribe of grasses known as bamboos achieved major importance as a source for food, timber, vessels, woven products and one of the first true papers.

The grasses are markedly different from other families in the plant kingdom. They are distinguished by their round stems with conspicuous nodes, usually hollow internodes, alternate two-ranked leaves and flowers borne within two bracts. Within the family, however, classification is often difficult, if fascinating, due to the intricate variations on this scheme.

Illustration on next page



Triticum aestivum
Wheat



Hordeum vulgare
Barley



Zea mays
Corn

Gramineae

24-R

Sugar Cane

Saccharum officinarum L.

Asia

Gramineae

(alt: Poaceae)

An extremely important member of the plant kingdom sugar cane yields not only sugar but many valuable commodities as by-products of its refining process.

In this process, the canes are first shredded and pressed to extract a juice laden with dissolved sugars. The juice is boiled or steamed with lime and phosphate to separate out impurities and then concentrated over heat or under low pressure to allow the sucrose to crystallize, leaving molasses to be drained off. Repeated centrifuging removes more molasses, some of which is subsequently fermented and distilled to produce rum. (Ethyl alcohol is another product of distillation.) The crystallized sucrose, light brown at this stage, is known as "raw" sugar. When washed and recrystallized it yields the primary product of the sugar cane plant: white, pure sucrose sugar.

The fibrous residue, known as "bagasse," is then used to fuel the sugar factories themselves or is manufactured into paper, cardboard or wallboard.

A giant member of the grass family, sugar cane is thought to have originated in the South Pacific. Now this perennial grass is known only in cultivation and today's crops are recent hybrids of several species of the genus *Saccharum*.

25-R

Mango

Mangifera indica L.

cv. Keitt

Southern Asia

Anacardiaceae

Mangos are the most popular fruits of the tropics, where they occupy the role enjoyed in temperate climates by apples. In their native India more than five million tons a year are grown for marketing locally or in nearby countries.

The mango is prevalent in Hindu ceremony, mythology and culture. According to legend, an entire grove of mango trees was provided by disciples to shade the meditating Buddha.

Although delicious, mangos are not widely consumed in Northern countries because shipping ripe fruits is difficult, and because unripe fruits have a disagreeable turpentine-like flavor. Also, unfortunately, the skin of the fruit and other parts of the plant is slightly toxic for some people, due to the presence of a substance similar to those poisons found in other members of this same family: poison ivy, poison oak and poison sumac.

26-R

Aloe vera

Aloe barbadensis Mill.

Mediterranean Region

Liliaceae

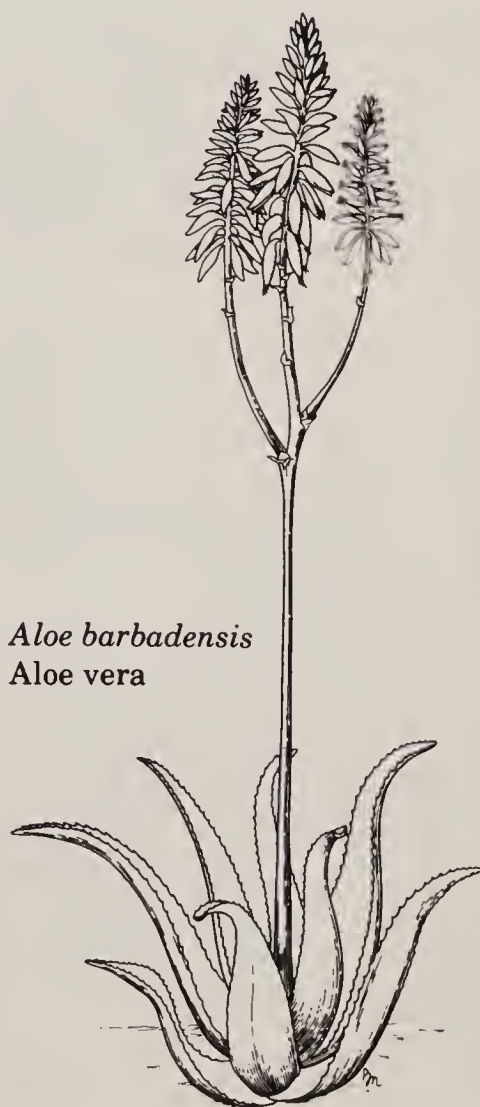
The origin of the "true aloe" is obscured by its extensive transplanting around the Arabian Mediterranean world. Often associated with superstition, from ancient times it has been planted in Egypt and other north African countries as a cemetery plant and boundary hedge. It is also hung over household doorways to ensure long life for those who live within.

The sticky juice of its leaves has long been used to treat skin disorders, from allergic rashes to shallow cuts and burns. Recently, its use has been extended to many cosmetic and household products.

Saccharum officinarum
Sugar Cane



Aloe barbadensis
Aloe vera



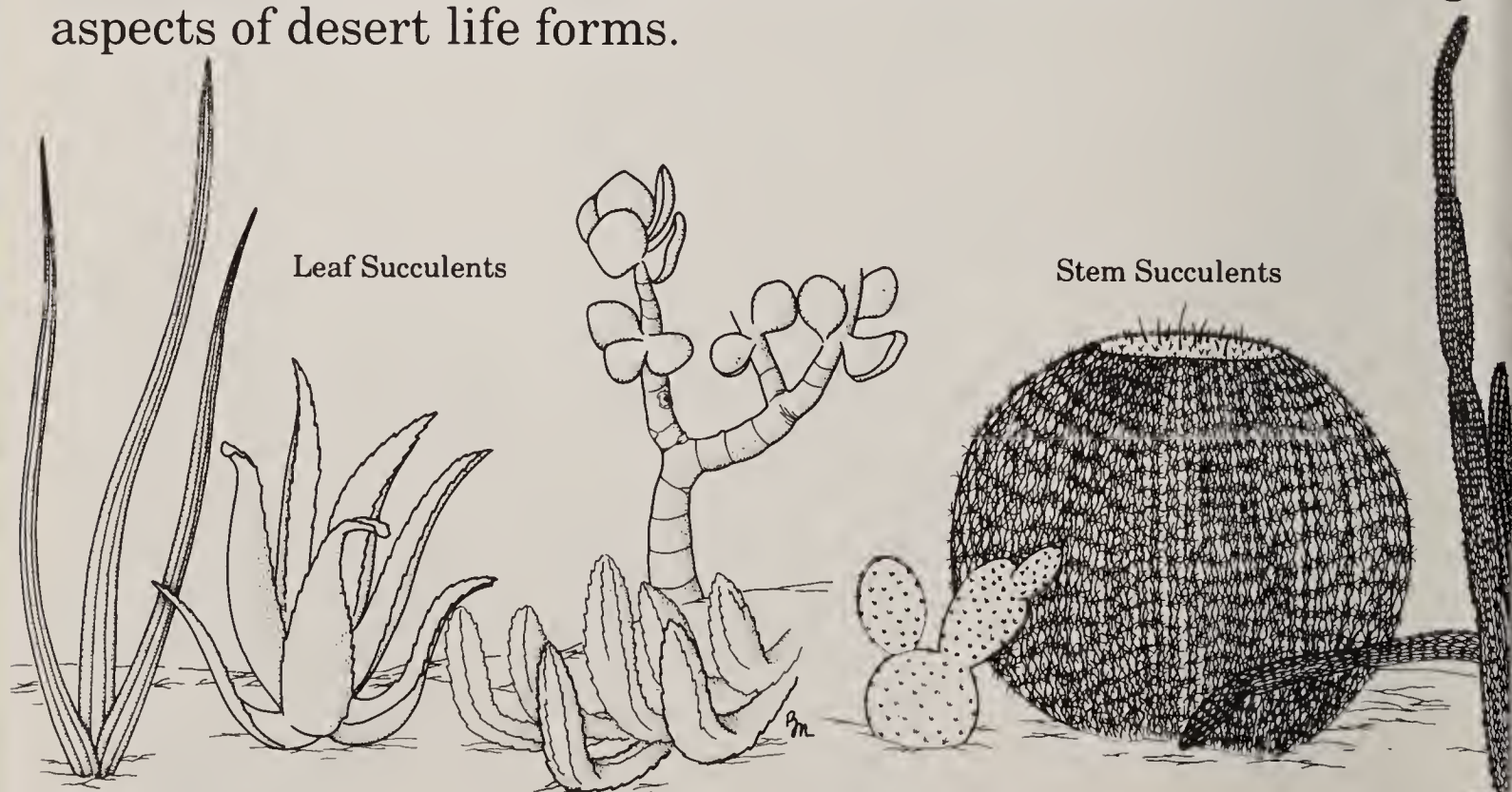
Succulents

Succulents are plants with fleshy leaves or stems, having enlarged cells for storing water in a viscous state. Most of them are from hot deserts but some are from arid grasslands and others from regions of high altitude.

A common misconception is that all succulents are cacti. The cactus family, native only to the New World, is but one that has developed this characteristic. Many other families little related to the cacti exhibit succulence. Plant groups in this hemisphere which have some succulent members are the sedums and crassulas in the Crassulaceae, the agaves and furcreas in the Agavaceae and the peperomias in the Piperaceae. In the Old World, principally Africa, are the euphorbias of the Euphorbiaceae, the aloes, gasterias and sansevierias of the Liliaceae and the stapeliad group of the milkweed family, the Asclepiadaceae.

Besides succulence, most of these plants exhibit other interesting adaptations to their harsh environments. To reduce transpiration, some have reduced their exposed leaf surfaces by developing spherical leaves, smaller leaves, or tightly overlapping leaves; others have eliminated their leaves altogether, carrying on the vital process of photosynthesis in the chloroplasts of their swollen stems. Most of these plants have waxy, water-saving coatings, or their skins are covered with spines or hairs that temper the atmosphere immediately next to their surface.

The wide variety of succulents, both from the Old and the New World, displayed here illustrates these and other fascinating aspects of desert life forms.



27-R

String of Beads

Senecio rowleyanus

Jacobs.

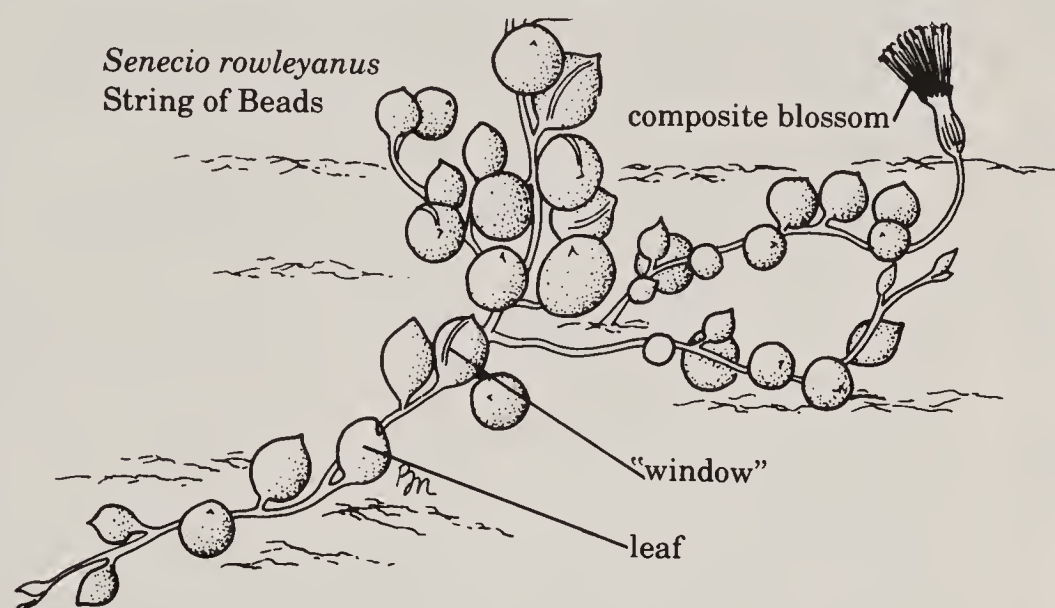
Southwestern Africa

Compositae

(alt: Asteraceae)

This strange plant with small globular leaves strung along its tough, wiry stem exemplifies plant adaptations to desert habitats like those found in its southwestern African homeland: Its succulent tissues store water, the spherical leaf forms reduce vulnerable skin area, and its low stature helps it escape drying winds. In addition, the thin crescent shaped "window" on each leaf aids in controlling the amount of desert sunshine that reaches the chlorophyll within the leaf.

Valued by succulent plant admirers, the string of beads is a prized ornamental for hanging baskets and for conservatory ground cover. Its unlikely shape helps illustrate the diversity within the vast sunflower family to which it belongs. Its relatives include such famous plants, valued or vilified, as lettuce, dandelion, thistle, artichoke, chrysanthemum and cocklebur.



You may now enter Marnie's Pavilion to enjoy the display of orchids and bromeliads there. Resume this tour after re-entering the Conservatory.

Head to your right down the path along the south side of the Conservatory.

28-L

Lignum-Vitae (Wood-of-Life Tree)

Guaiacum officinale L.

West Indies

Zygophyllaceae

The wood of this tree, extremely hard and durable, has been used to make pulley blocks, mallets, cogs, rollers and bowling balls. Bearings made of it are self-lubricating, even under water, because of naturally occurring resins. Because it is very heavy, with a specific gravity of up to 1.25, most lignum-vitae wood sinks in water.

In the 1490s, Indians of the Caribbean, home of the lignum-vitae, told the Spanish of its medicinal properties and, subsequently, an extract of its resin was used in Europe to combat a syphilis epidemic prevalent into the 16th century. Only recently in this century has a more effective treatment been developed.

Its attractive blue flowers are the national floral emblem of Jamaica.

29-L

Sacred Bo Tree

Ficus religiosa L.

India

Moraceae

Often found near temples and shrines, the sacred bo tree has been planted in most of the villages of tropical India. There it is venerated. Buddhists believe that in the 6th century B.C. Guatama Buddha, while meditating under the branches of this fig, received his divine enlightenment. Orthodox Hindus consider the cutting of a single branch from this tree as irreverent as mistreating one of India's sacred cows.

The Dogbane Family: Apocynaceae

The final distinction between medicine and poison often disappears, and plants of this family yield many substances that are used as both. Societies of all continents have used the deadly sap from various members of the Apocynaceae to tip their arrows or spears; they've also used the same substances, and the sap of other plants of the family, as curatives. Beneficial uses continue today in the treatment of heart and vascular disorders and of some cancers.

Though the family is primarily tropical, it receives its common name from the dogbane, or "dog's bane," of Europe, so called from antiquity because of its reputed ability to repel rabid canines. (By the same token, it was also said to be an amulet against werewolves, a property even more difficult to substantiate.)

Among the nearly 1,300 species in the Apocynaceae are many with pretty, often fragrant flowers. Some of these ornamentals included in our Conservatory are the frangipani (*Plumeria rubra*) whose flowers are strung into leis in Hawaii, the oleander (*Nerium oleander*), the Natal plum (*Carissa grandiflora*) which has edible fruit, the Madagascar palm (*Pachypodium lamerei*) with its spiny, swollen "elephant's foot" stem, and the vine *Allamanda cathartica*.

Outdoors in this region are grown two "periwinkles" of the family: a blue or white-flowered perennial ground cover, *Vinca minor*, and an annual bedding plant with white or pink flowers, *Catharanthus roseus* (synonym: *Vinca rosea*). Colorado's native dogbane (*Apocynum cannabinum*) is known as Indian hemp; its tough, stringy stems yielded fibers useful to native Americans.

30-L

Bushman's Poison

Acokanthera oppositifolia
(Lam.) Codd
(*A. venata* Don)
Southeast Africa
Apocynaceae

Tribal hunters use the sap from this African shrub as a dressing for their arrow tips to bring nearly instant death to their prey. It is so poisonous that it is fatal if absorbed through the skin, even when dried to a powder. The decoction obtained from boiling its leaves and wood chips is also sometimes mixed with venoms of snakes and spiders or with crocodile bile to make very effective variations.

The fruits, too, are dangerous, though the pinkish white flowers offer a welcome winter fragrance.

31-R

Saguaro

Carnegiea gigantea
(Engelm.)
Britt. and Rose
Cereus gigantea Engelm.)
Southern Arizona,
Southeastern California,
Northern Mexico
Cactaceae

Across the deserts of extreme southwestern United States and northern Mexico, these immense barrel cacti dominate the landscape, sometimes reaching heights of 40 to 50 feet. They offer within their hollow bodies and candelabra-shaped branches home and protection for many small desert birds, mammals and lizards. Bats drink nectar from their scented white blossoms and thereby pollinate the plant at night.

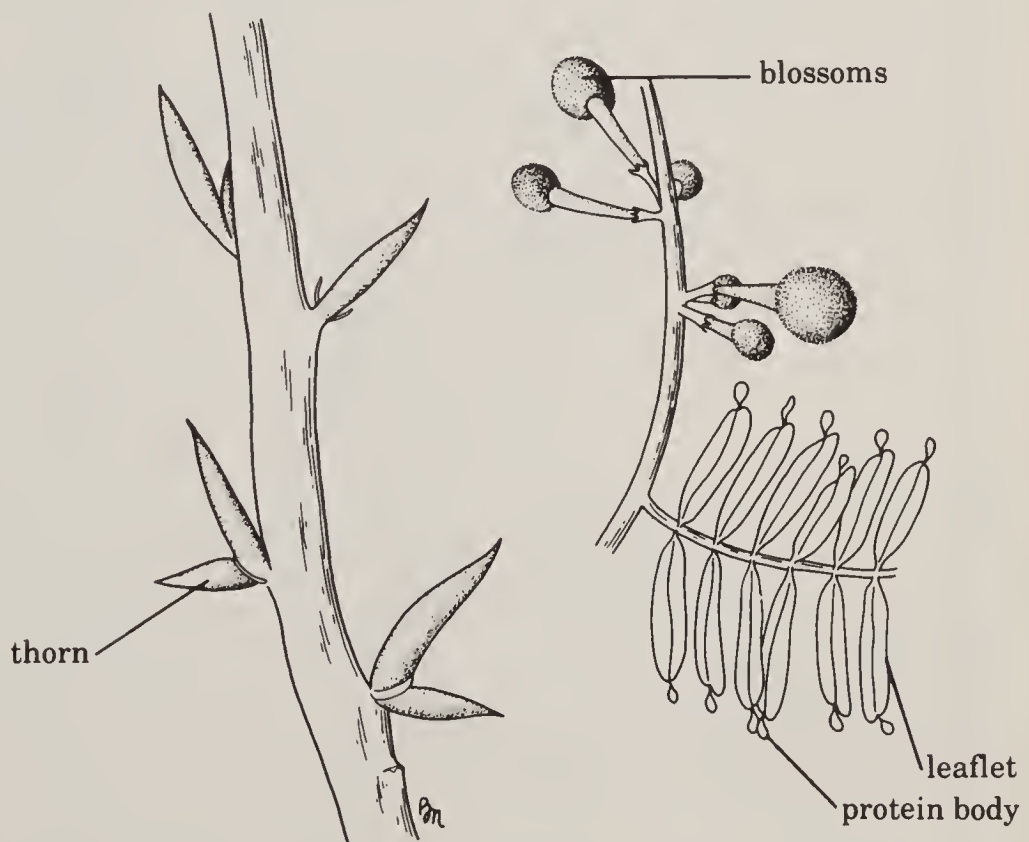
The plants are beneficial for humans as well: Jams, confections and fermented beverages are made from the edible berries.

32-R

Bull's Horn Acacia

Acacia cornigera
(L.) Willd.
Mexico
Leguminosae
(alt: Fabaceae)

This shrubby tree receives its common name from the shape of its inflated spines. However, in its dry, tropical home in eastern Mexico it is called *arbol de las hormingas*, or "tree of the stinging ones," in reference to the small vicious ants that inhabit the hollow horns. They feed on tiny waxlike bodies of protein and oil that the plant produces at the tip of each delicate leaflet. In return, their pugnacious presence offers protection for the plant from animal predators.



Acacia cornigera
Bull's Horn Acacia

33-R

Variegated Century Plant

Agave americana (L)

var. *variegata*

Mexico

Agavaceae

Our specimen with its yellow-bordered leaves is one of the many attractive variations of the common grayish green agave widely grown in arid regions of Mexico. Fibers extracted from its tough leaves contribute to important cottage industries, helping to manufacture goods from rough strings to ropes to fine blouses and decorated bags. Native to the Mexico-Texas border area, archaeological records reveal that the century plant has been an important cultivated crop for over 7,000 years.

The assumption that it blooms only every hundred years is false; in reality it blooms in 7 to 10 years from seed. Interestingly, after blooming, the plant dies, leaving behind seeds and offshoots to perpetuate its species. This characteristic, found in numerous other plants, is known as monocarpism, and literally means "once-fruiting."

34-R

Jojoba

Simmondsia chinensis

(Link) Schneid.

Southwestern USA

Northern Mexico

Buxaceae

The increasing scarcity of sperm whale oil has led to an intensive search for high quality substitutes. Since the 1970s that search has focused on the jojoba plant. Its oils have properties very similar to those of the endangered cetaceans, yet this plant offers the attractive possibility of being cultivated as a renewable resource. Currently, jojoba is an ingredient in lubricants for high-speed machinery, shampoos and other cosmetics, as well as polishes and waxes for furniture, floors and automobiles.

Since it is native to deserts, this tough, twiggy shrub may be adapted for agricultural development in otherwise underutilized arid lands of the Southwest.

Its specific epithet *chinensis*, meaning "from China," is the mistake of an early botanist.

35-L

Loquat

Eriobotrya japonica Lindl.

China, Japan

Rosaceae

This attractive, shrubby tree is widely grown for its fruit and as an ornamental. Its dark green, leathery older leaves contrast strikingly with its gray-green, downy younger leaves. Sweet-scented dingy white flowers are partially hidden among woolly hairs.

The loquat has been grown in China and Japan since antiquity. Its fruit has a flavor which reminds one of sweet cherries and apples, to which it is closely related. Its texture is similar to a peach. Loquats may be eaten fresh or used for making jellies, preserves or pies.

36-L

Cotton

Gossypium barbadense L.

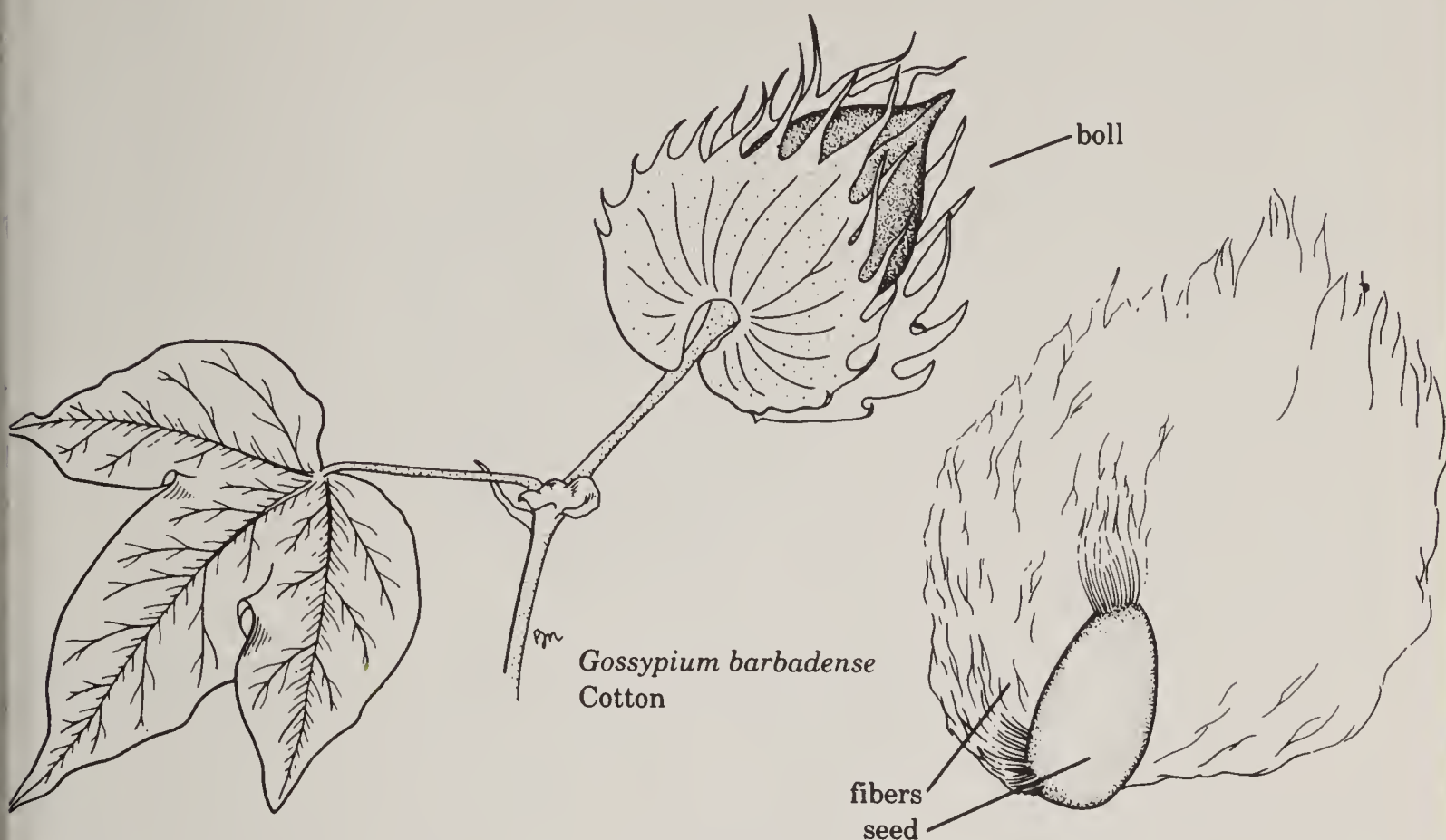
Central America

Malvaceae

World production of cotton, our most important vegetable fiber, depends on many species and races of *Gossypium*, each suitable for different purposes. Some cottons have only "fuzz," smooth, unspinnable fibers; others have "lint," flattened, spiraled, and spinnable; still others have both. These fibers are an outgrowth of the seed coat within the pod, or boll. Cotton lint is usually spun into textiles, while fuzz is used in felts.

Nearly pure cellulose, both types of fiber are

processed into rayon, photographic film and sausage skins. Cotton seeds are pressed to yield oil for salads, cooking, margarine and industrial uses. By-products from the residue are used either as fertilizer or a high-protein food for cattle.



37-L

Macadamia Nut
Macadamia ternifolia
 Muell.
 Australia
 Proteaceae

Macadamia nutmeats are highly esteemed and very expensive. Despite expanding commercial cultivation in Hawaii, they remain non-competitive with other subtropical nuts such as cashews and almonds. Extracting the meat from their extremely hard shells is difficult, so growers are seeking thin-shelled varieties.

The macadamia tree is native to eastern Australia, the continent that is home for a majority of species in the fabulous protea family. Other species are found in South Africa and temperate South America. This extreme southern distribution argues for the antiquity of the family — that it probably evolved before the continents reached their present locations after splitting apart from a common land mass.

38-R

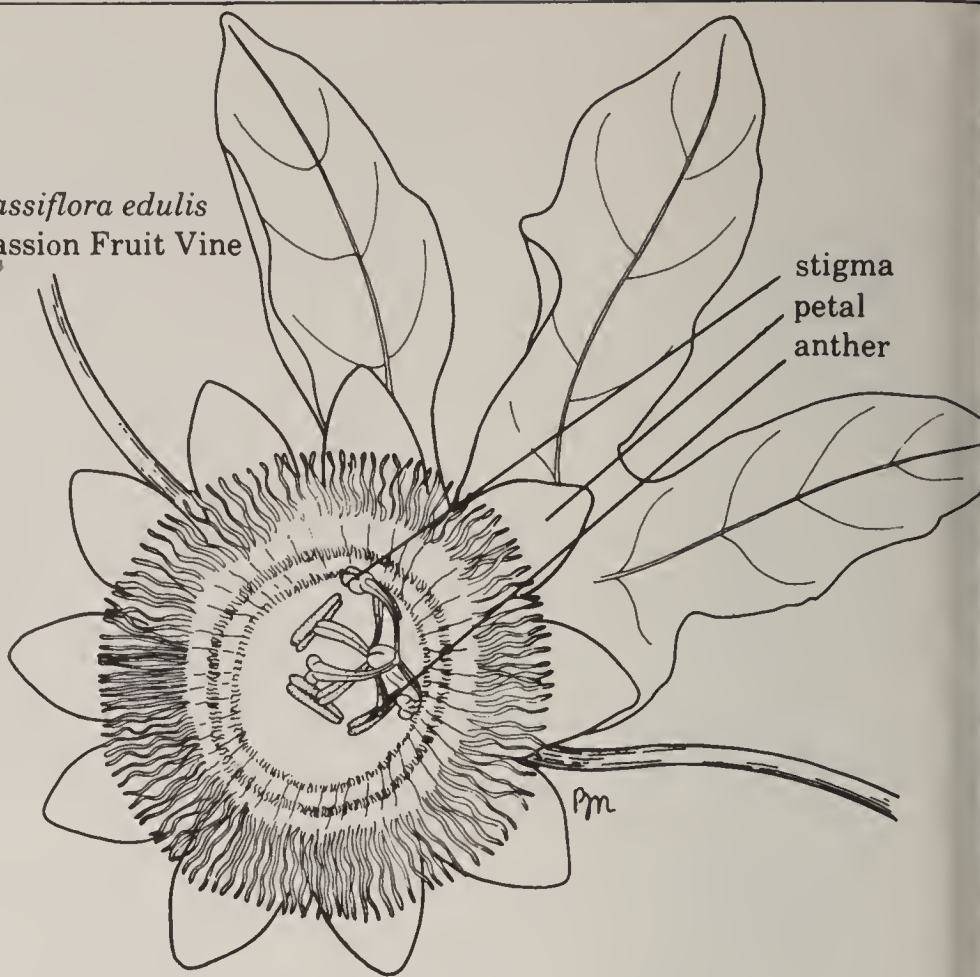
Passion Fruit Vine
(Purple Granadilla)
Passiflora edulis Sims
 Brazil
 Passifloraceae

Christian missionaries to the New World named these amazingly intricate blossoms "passionflowers" because they fancied in the complex floral structures representation of certain elements of the crucifixion and suffering, or "passion," of Christ. Details of their depictions are varied, but usually included in their descriptions are 10 apostles (Judas and Peter having been excepted), the crown of thorns, and the Holy Trinity.

This edible species is from Brazil, but is now grown commercially in Kenya, New Zealand, Australia and Hawaii, mainly for the refreshing juice extracted from its fruit.

Illustration on next page

Passiflora edulis
Passion Fruit Vine



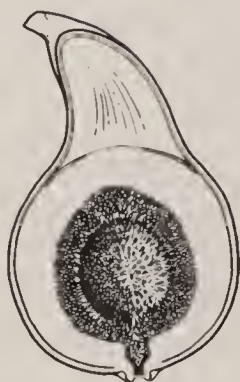
39-R

Common Fig
Ficus carica L.
Mediterranean Region
Moraceae

Historically, figs have played an important nutritional role in the rich history of the region extending from the Caspian Sea southward and westward around the Mediterranean Sea. High in sugar content, the fruits were easily dried and preserved for consumption during non-fruiting seasons. For this reason, they have been valued for more than 5,000 years and numerous citations exist in the Bible.

The fruit is a syncarp. Scores of minute male and female flowers bloom and mature within the dark interior of a fleshy receptacle. Female flowers, if pollinated by the fig wasp, develop into the seeds familiar in commercial figs. For most commercial edible figs, cross fertilization is necessary with a particular non-edible variation of the species called a caprifig. Our Conservatory's variety, however, is one that develops ripe fruit on its own.

Ficus carica
Common Fig
syncarp



The Myrtle Family: Myrtaceae

Like almost every other member of the family, the leaves and bark of *Myrtus communis* (the common Mediterranean myrtle that lends its name to this family of woody plants) contain an abundance of essential oils, making it pleasantly fragrant.

Essential oils contained by other plants of the family have made them valuable for use in cosmetics, flavorings and medicine. The most important of these is the clove tree (*Syzygium aromaticum*) whose unopened, dried flower buds are marketed as a spice. The dried unripe fruits of *Pimenta dioica* provide another culinary spice, allspice, so named because it seems to combine the flavors of cinnamon, clove and nutmeg. The leaves of the bay tree (*P. racemosa*) are nearly four percent oil by weight; they yield bay rum when distilled, the soothing, antiseptic ingredient included in many perfumes and skin conditioners. In Australia and on neighboring islands grow gum trees (*Eucalyptus* species) that yield not only essential oils, but timber, firewood and tannins.

The floral characteristics that unify this family of about 3,000 species are an inferior ovary, the four or five petals of the regular flowers, and a single style but numerous stamens whose filamentous nature causes the flowers to look like small brushes. Indeed, one group of these plants is called bottle-brushes. In our Conservatory we have the yellow bottlebrush (*Callistemon sieberi*) and the weeping bottlebrush (*C. viminalis*).

Other interesting members of the family displayed here are the pineapple guava (*Feijoa sellowiana*), the jaboticaba (*Myrciaria cauliflora*), the paper-bark, or cajeput tree (*Melaleuca leucadendron*) and the rose apple (*Eugenia jambos*). No myrtles are hardy here outdoors.

40-R

Guava

Psidium guajava L.

Tropical America

Myrtaceae

Containing from two to five times the vitamin C of fresh orange juice, this pear-shaped fruit is cultivated for eating out of hand, primarily for local markets, and for processing into jelly, nectar and dehydrated juice, a vitamin C diet supplement.

The wild guava found in the American tropics makes the best preserves and pastries. By a process of selection growers have developed trees with a larger fruit with attractive salmon pink flesh. The cultivated fruit has less grit and fewer seeds and is better for fresh consumption. Hawaii is now the center for improving this fruit as a commercial crop.

The Ginger Family: Zingiberaceae

Entirely tropical and subtropical in origin, members of this family provide a number of important spices and dyes. The deep yellow underground tubers of *Curcuma domestica* contribute turmeric, an important ingredient in curry and a brilliant golden dye used in ceremonial body painting. The dried fruits and seeds of *Elettaria cardamomum*, known as cardamon or cardamom, are imported by Arabs to flavor their coffee for its supposed cooling effects and by Scandinavians to provide their favorite spice for cakes, pastries and confections. Ginger itself is extracted from the resinous, aromatic underground stem, or rhizome, of *Zingiber officinale*. In fact, the name "zingiber" is derived from the Sanskrit word meaning "horn-shaped," in reference to these rhizomes. These and other species, of the nearly 1,400 in the family, have also been used by various societies in their practice of medicine.

Perennial plants, the gingers have their leaves aligned attractively in double ranks along slender stems. Their flowers often striking, consist of three sepals, three petals and six stamens; parts may be joined together, arranged irregularly or nestled among heavy bracts, sometimes making their classification difficult. These floral features may be noticed on some of the members of the family which bloom sporadically throughout the year in our Conservatory: shell ginger (*Alpinia speciosa*), torch ginger (*Phaeomeria magnifica*), the spiral ginger (*Costus speciosus*) or the wonderfully fragrant garland flower of India (*Hedychium coronarium*).

41-R

Ginger

Zingiber officinale Roscoe

Tropical Asia

Zingiberaceae

One of the earliest spices known to Europeans, ginger like so many foods and flavorings, was brought by Arabian traders from India and the Pacific Islands. Primarily identified with Eastern cuisines, ginger is a major ingredient in Indian curry and is indispensable in Chinese cookery. Yet, from gingerbread to ginger ale, it imparts a distinct spicy flavor to many Western foods as well. Cut from the underground stem of the plant, ginger is used raw, candied or powdered.

42-L

Panama Hat Plant

Carludovica palmata Ruiz
& Pav.
Central America to
Bolivia
Cyclanthaceae

This palmlike plant is related to the true palms and to the aroids. The floral structure is a spadix on which are arranged spirals of individual male and female flowers.

In its Andean homeland the large leaves are used for thatch, mats, baskets, brooms and, most significantly, hats, especially the Panama hat. This hat, although made in Ecuador, acquired its erroneous name when transported from South America through the Panama Canal. Millions are exported annually.

43-L

Ceriman (Mexican Breadfruit)

Monstera deliciosa Liebm.
Mexico, Central America
Araceae

With immense deeply cut, heart-shaped leaves, this attractive tropical vine has long been a popular ornamental plant. In its native Mexico and Central America it is favored as well for its delicious fruit. Although the fruit appears as a single conelike structure, it is actually a compound arrangement of many fruits crowded along a central axis, much like those of a pineapple.

Tasty though it is, it must be eaten fully ripe with all extraneous flower parts removed to avoid the painful results of ingesting oxalic acid crystals that are present in the unripe fruit.



Turn to the right, toward the steps leading down to the large pool.

44-L

Australian Tree Fern

Sphaeropteris cooperi (F.
J. Meull.) Tryon
(*Alsophila australis*
R. Br.)
Australia
Cyatheaceae

With their majestic crowns of lacy fronds, sometimes five to six feet long, tree ferns are among the most beautiful of non-flowering plants. Their rough, hairy trunks, partially composed of thick roots, may, with age, reach an imposing height of 20-25 feet. This species is a native of eastern Australia, New Zealand and Tasmania where it thrives in wet gullies and mountainside seepages.

Tree ferns were once abundant in the Carboniferous Period and were among the dominant plants in the swamp forests that covered much of the Earth around 300 million years ago.

The Arum, or Aroid Family: Araceae

The true arums from which the family inherits its common name inhabit the seasonally moist forest floors and bogs of Europe, but the most familiar members of the family are the tropical ones, many of which have become common as houseplants: philodendrons, dieffenbachias (dumb canes), pathiphyllums and anthuriums. (A mark of their familiarity is the fact that their genus names have entered our vernacular.)

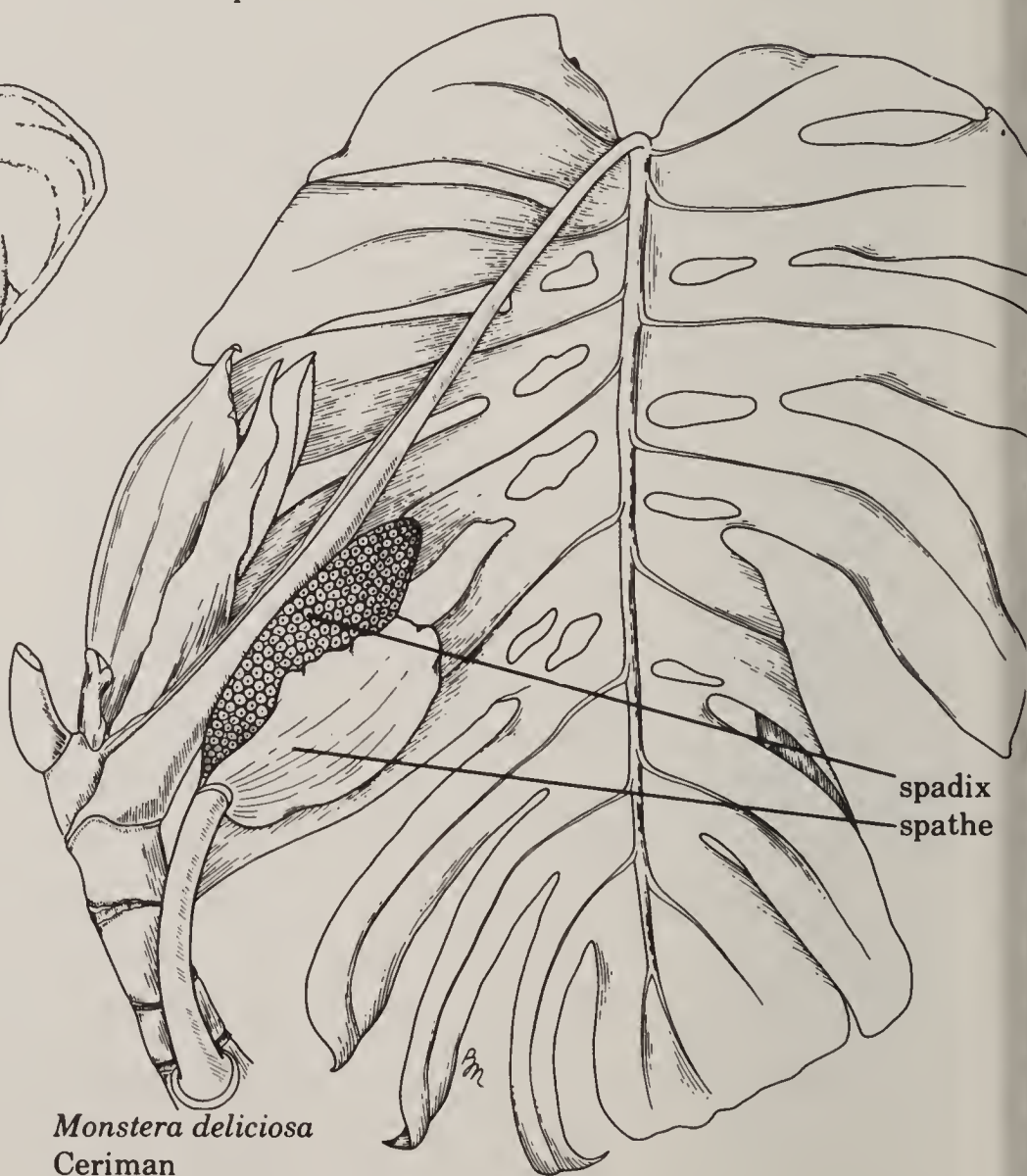
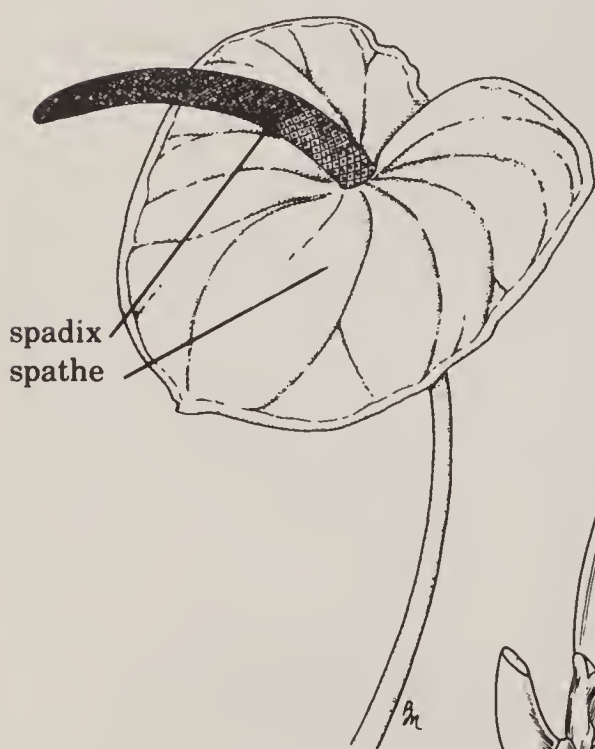
The floral characteristics that distinguish them as a family are the spadix, a fleshy central stalk on which are arranged the tiny male and female flowers, and the spathe, a petallike modified leaf which more or less encloses the spadix. They also

share, to a great extent, the irritating substance oxalic acid, and the green parts of all members should be considered toxic.

Few of these plants besides taro (*Colocasia esculenta*) are of economic importance except as dramatic ornamentals of the florist trade. The blossoms of both anthurium (*Anthurium andraeanum* hybrids) and calla lily (*Zantedeschia aethiopica*) are used as cut flowers. Our Conservatory exhibits many examples of the houseplant genera listed above; in addition, you may find the Mexican breadfruit (*Monstera deliciosa*), Japanese sweet flag (*Acorus gramineus*) and arrowhead plant (*Syngonium podophyllum*).

Outdoors in our Rock Alpine Garden are grown examples of the genus *Arum* as well as several species of jack-in-the-pulpit (*Arisaema* species). The Front Range of Colorado is also home of the sweet flag (*Acorus calamus*), but it is becoming increasingly scarce here due to urbanization.

Araceae
Anthurium sp.



Monstera deliciosa
Ceriman
Split-Leaf Philodendron

45-R

Taro (Eddoe) (Dasheen)

Colocasia esculenta (L.)

Schott

Tropical Asia

Araceae

The bulblike stems, or corms, of the taro plant are edible and are a major root crop for millions of people in the tropics. Although textures and flavors may vary, the many varieties generally grown fill a dietary niche occupied by potatoes in temperate climates. High in easily digested carbohydrates, taro also offers a moderate supply of vitamins and protein. The Polynesian poi, made from fermented corms, is a famous native dish of Hawaii.

The plant has large leaves shaped like a shield or elephant's ear, another common name for it.

46-L

Black Bamboo

Phyllostachys nigra

(Lodd.) Munro

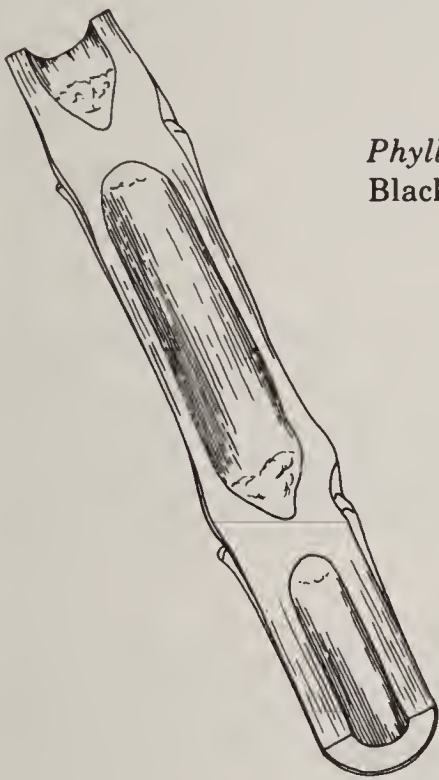
China, Japan

Gramineae

(alt: Poaceae)

Many forms of this handsome plant are grown in Japan where its name is *Kuro-Chiku*. It is prized both for its stems, which may range from black to purple, and for its leaves, which may exhibit different patterns of creamy white or yellow variegation. In the spring its young shoots are edible. One of the smaller bamboos, it rarely grows above 10 feet, though it spreads by way of its underground rhizomes to form broad clumps.

Like other bamboos, its stem is hollow between the swollen nodes.



Phyllostachys nigra
Black bamboo



47-R

Egyptian Paper Plant

Cyperus papyrus L.

Africa

Cyperaceae

Growing along the shores of Lake Victoria and in the quietly flowing shallows of the Nile River, this stately, graceful plant is one of the most beautiful of the Earth's aquatics.

Around the year 2750 B.C. the Egyptians made an important breakthrough when they developed a process for making a paperlike product from its pithy stems: Alternate layers were pressed together, sun-dried and smoothed with animal teeth or shells to provide "papyrus," the first writing material of its kind. Noted for its very buoyant stems, this plant is the bulrush mentioned in the Bible.

48-L

African Tulip Tree

Spathodea campanulata

Beauv.

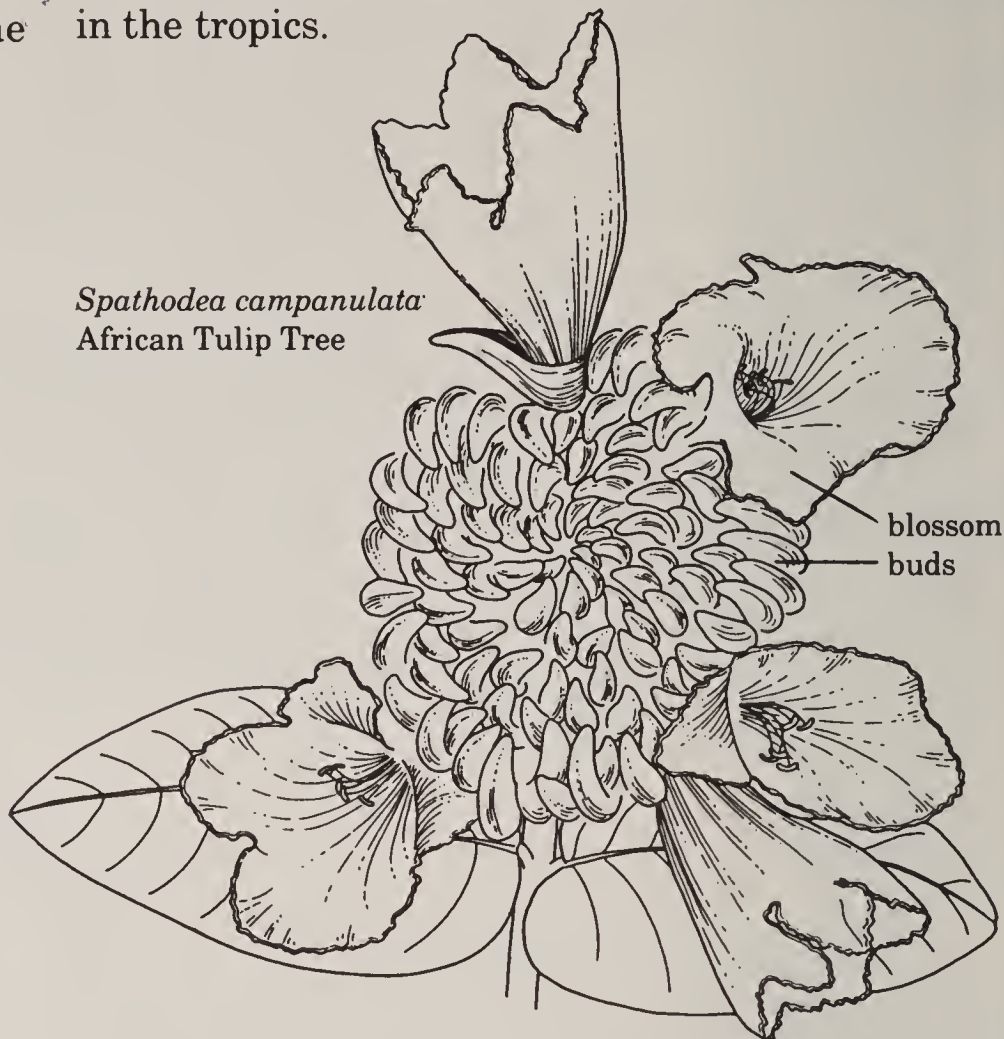
Africa

Bignoniaceae

The large frilly, cuplike blossoms of this handsome tree are borne in fiery red clusters that glow so vividly from the branch tips they are visible for great distances.

Commonly called flame trees, these magnificent plants, some towering 80 feet, have been planted extensively for dramatic effect in their native Africa and elsewhere in the tropics.

Spathodea campanulata
African Tulip Tree



Now, return to the entrance and retrace your first steps up the main pathway, until you reach the first branch in the path to the right. Here you will find the next plant described in this booklet.

(You will then continue up this path toward the balcony.)

49-R

Rangoon Creeper

Quisqualis indica L.

Burma to Philippines

Combretaceae

Its generic name — from *quis*, meaning “who” and *qualis*, “what kind” — alludes to the confusing growth habit of this interesting plant. It grows first as a shrub then it sends up a shoot from its roots that becomes an aggressive vine. In its woody maturity it develops large hooked thorns by which it supports its clambering stems.

The flowers too are changeable. They open creamy white but change over several days through shades of pink to crimson. At night they have the fragrance of a mixture of very ripe fruits.

50-R

Olive Tree

Olea europaea L.

Mediterranean Region

Oleaceae

The many biblical references to the olive tree and to olive oil, as well as the numerous ancient oil presses still scattered over Asia Minor, signify that olives have been agriculturally important there for over 5,000 years. In fact, if the dove sent out by Noah in the story of the flood did, indeed, return with an olive branch in its beak, this tree was one of the first to re-emerge after the legendary great deluge. Orchards more than 1,000 years old remain today, testifying to the olive tree's tenacity in the arid lands of the eastern Mediterranean.

Olive oil is pressed from the tree-ripened fruits. For table use the fruits are picked green and variously treated with lye solutions and brine. Spanish-style olives have been protected from air, preserving their green coloring, while California-style olives have been exposed to air, which turns them black.

The Pea Family: Leguminosae (alt: Fabaceae)

The third largest family in the plant kingdom, with 14,000 to 18,000 species, the legume family is characterized by its fruit, aptly called a legume. (Typical examples are a peanut or a pea pod.) Though the flowers are all alike in certain important respects (their ovaries are superior, with a single cavity and style), there are three major divisions based upon different superficial appearances: typically winged pealike or butterfly flowers; irregular, large-petaled flowers with prominent arching stamens, and flowers with all parts very reduced except for their numerous hairlike stamens. Some botanists use these divisions as the basis for three separate families.

A valuable attribute of the legumes is their host relationship with bacteria of the genus *Rhizobium*. These bacteria are able to fix atmospheric nitrogen, making it available to the legume plants as well as increasing the nitrogen in the soil. This ability to increase fertility is of inestimable importance for agriculture.

The family is second only to the grasses in importance for food production, and edible species have been introduced into agriculture from all over the world. Broad beans, or fava beans (*Vicia faba*), garden peas (*Pisum sativum*) and lentils (*Lens culinaris*) came from southern Europe and the Near East; lima beans (*Phaseolus limensis*), kidney beans (*P. vulgaris*) and the scarlet runner bean (*P. coccineus*) originated in the tropical New World, and the black-eyed peas (*Vigna unguiculata* ssp. *unguiculata*) and soybeans (*Glycine max*) were provided by Asia.

One of the favorite trees in our Conservatory is the powder puff (*Calliandra haematocephala*), so called because its flower heads consist of a multitude of protruding stamens. Outdoors

the family is well represented with legumes that range from alfalfa (*Medicago sativa*) to the black locust tree (*Robinia pseudoacacia*).

Leguminosae
Vicia faba



51-R

Carob (St. John's Bread)

Ceratonia siliqua L.
Mediterranean Region
Leguminosae
(alt: Fabaceae)

Biblical and language scholars attribute two references in the King James New Testament to this small tree of the Middle East: Its seed pods were probably the "husks" eaten by the Prodigal Son in the Book of Luke and, also, the "locusts" that sustained John the Baptist as related by Matthew.

These fruits contain a sugar-rich pulp used extensively as animal fodder, and are also eaten by people. When dried and ground the pulp becomes carob which has gained popular favor as a chocolate substitute.



This ends your self-guided tour of Boettcher Memorial Conservatory. After you enjoy the view from the balcony, you may exit through the doors behind it where you will find stairs leading down again into the lobby outside our gift shop.

Thank you for your visit.

bold-faced headings and numbers indicate those plant groups or families that are given major treatment. Numbers in parentheses following headings indicate locations; for details please refer to page 3. An asterisk (*) following a number indicates a line drawing.

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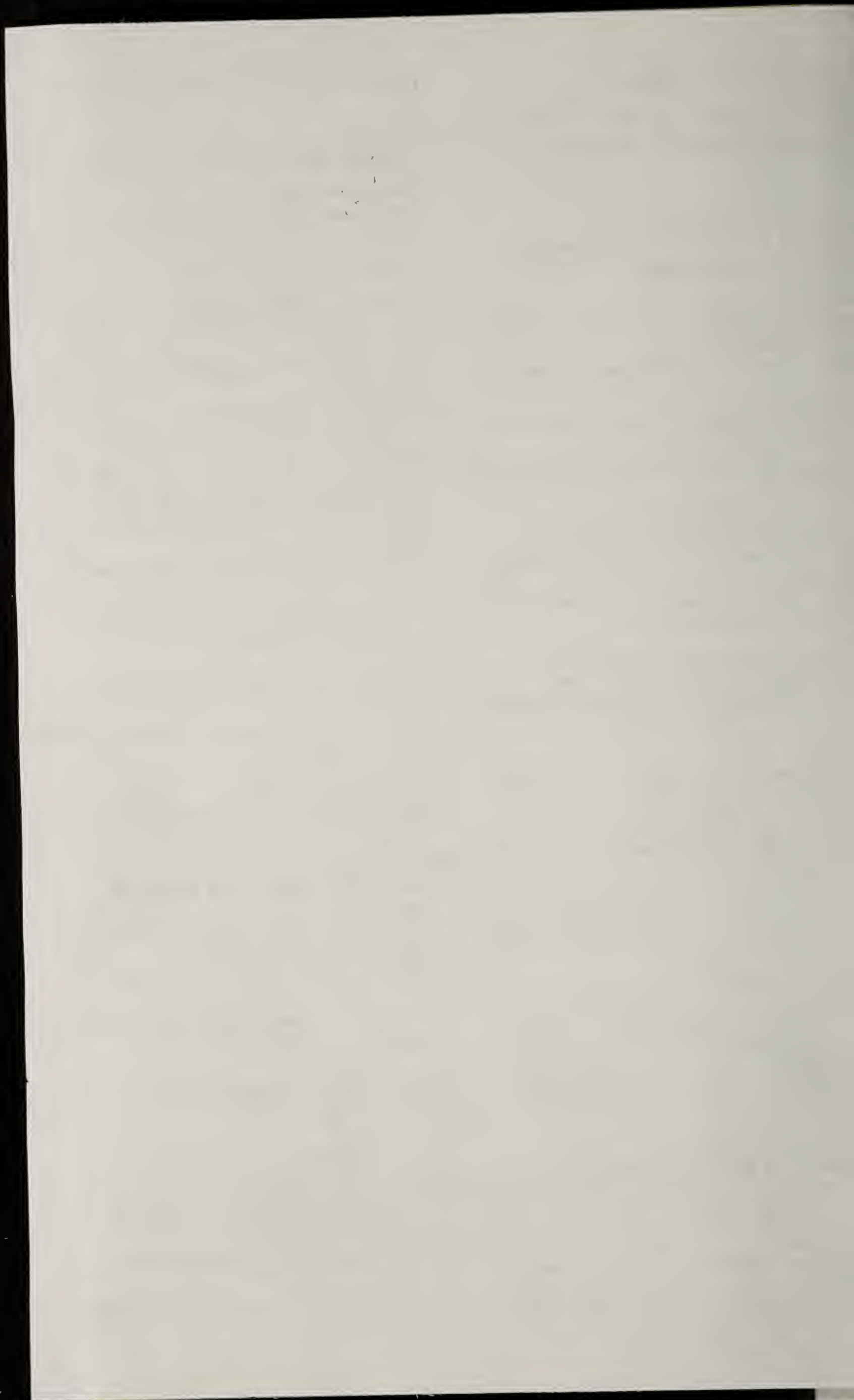
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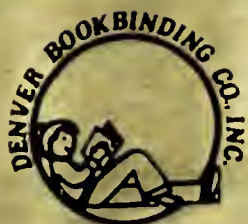
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